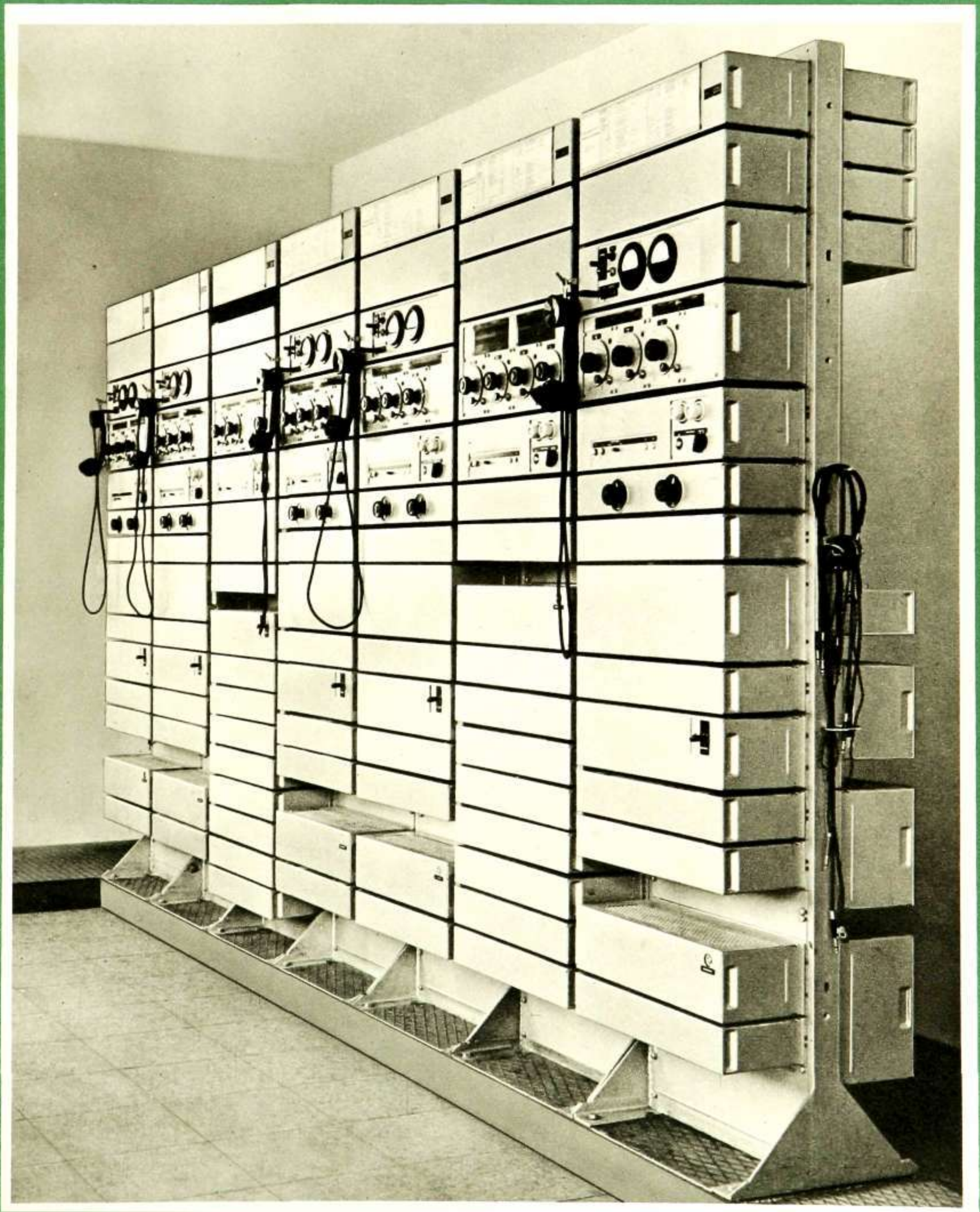
Ericsson Review



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New Carrier Frequency Systems for Telephony and Remote Metering and Control on Power Lines

S RODHE, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

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Power distribution undertakings need rapid and reliable long distance communications. This requirement has been intensified by the increase of collaboration between enterprises, the great growth in number and size of power stations and the still longer distances of transmission. Modern carrier frequency technics now enable the power lines themselves to be used for this transmission of speech and signals. The fact that a single carrier frequency channel can be employed for many different transmission purposes such as telephony, remote metering and control, teletyping and selective line protection, makes it possible to reduce the costs for each communication to such an extent that carrier frequency transmission on power lines may be economical even on short distances.

In the present article an account is given of the economical and technical essentials of carrier frequency transmission, the carrier frequency systems for power lines of L M Ericsson's make are described and the planning of carrier frequency communication networks is treated briefly.

The Need of Telecommunication

To enable the central management of a power distribution undertaking to direct operation in the most rational way it must have facilities for surveying the conditions at the different parts of the power network and accommodating its measures to changes in the state of the network by giving orders to the substations.

Telephone communication enables verbal reports and orders to be given; teletype communications make possible giving in writing of the more important information. By remote metering and control communications, measure readings are transmitted from the substations and the positions of controls for the different apparatus at those stations are indicated in the main station. Moreover turbines, generators, breakers etc. may be regulated

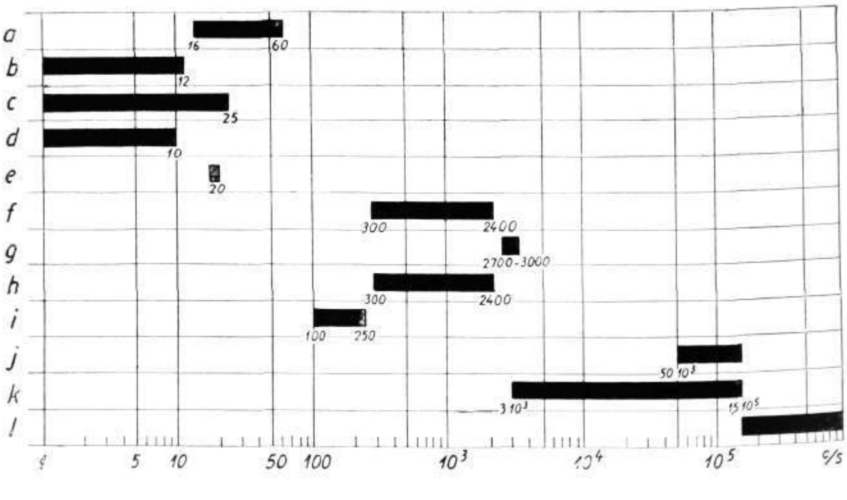

Fig. 1 X 6141
Frequency chart

a power distribution
b remote metering and control
c teletyping
d impulses of the automatical telephone equipments
e ringing signal
f telephone speech
g superimposed voice frequency impulse channels
h voice frequency impulse channels
i sub-audio voice frequency impulse channels
j carrier frequency transmission on power lines
k carrier frequency transmission on telephone lines as well as radio telegraph transmission
l broadcast transmission

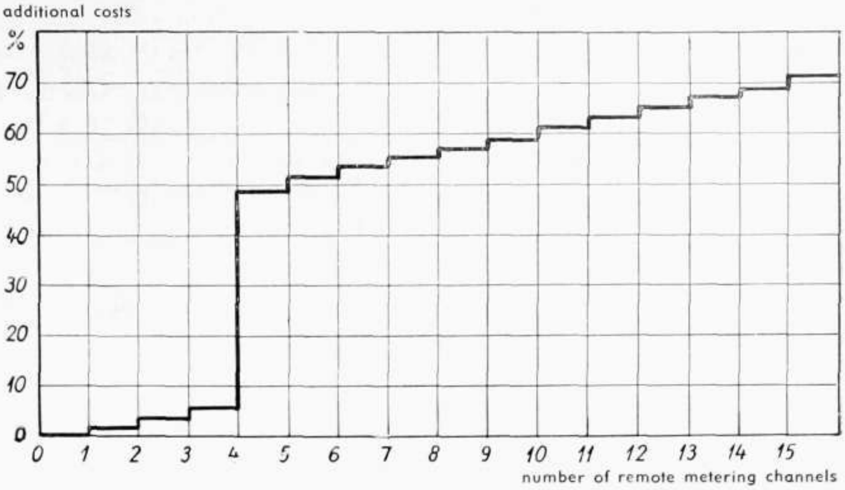

Fig. 2 X 6142
Additional costs of remote metering and control channels calculated as a percentage of the fundamental cost of the telephone channel equipment

remotely and handled manually or automatically. By means of telecommunication channels for selective line protection, defective line sections may be disconnected momentarily from the network.

All these communications are generally provided by alternating current or impulses of different frequencies and each of them having its special demand upon frequency space as per Fig. 1. Thus, in order to give good intelligibility, a telephone communication requires the efficient transmission of voice frequencies within the range 400—2000 c/s. Frequencies outside this frequency range contribute only slightly to the intelligibility. Even narrower frequency ranges may be satisfactory, but the human voice will then loose its characteristic acoustic quality, which may therefore make an otherwise wellknown voice difficult of recognition. In order to ensure that the above-mentioned frequency range will be effectively transmitted on the line, even for communications over very long distances comprising several cascade-coupled telephone sections, the frequency range of every section comprised in the communication circuit ought to embrace 300—2400 c/s. To attract attention in the called station, a ringing signal with a frequency of about 20 c/s is required. In cases, when the telephone equipments are built for automatic switching by means of the telephone instrument dial, impulses with a frequency of about 10 c/s are transmitted between the stations. The ringing current is then produced locally in the far station and is transmitted to the called subscriber by mediation of the impulses from the automatic exchanges.

Teletyping is carried out by telegraph impulses with a maximum impulsing frequency of about 25 c/s.

On the channels for remote metering and control also, impulses are transmitted. The intensity method often used for shorter distances, in which the transmitted quantity is represented by an alteration of the amplitude value of a current or a voltage, cannot be used generally for longer communications by reason of the variations of the resistance and the attenuation of the line. The impulse frequency is generally not higher than 12 c/s and is often considerably lower. In the impulse transmitting method the transmitted quantity may be represented by the length of the impulses, the number of impulses or by the impulse frequency and consequently reference is made to the impulse time method, the impulse number method and the impulse frequency method. For remote metering, the impulse frequency method is used very often. The transmitter consists of a rotary electricity counter driven by a current proportional to the measuring value. The electricity counter is equipped with a contact device or commutator, which divides a voltage or current into impulses, the frequency of which thus depends upon the rotation velocity of the counter and in that way will be proportional to the measuring value. At the receiving end, the impulses influence a relay the contacts of which deliver a D.C. voltage that charges condensers in series with a D.C. instrument. The

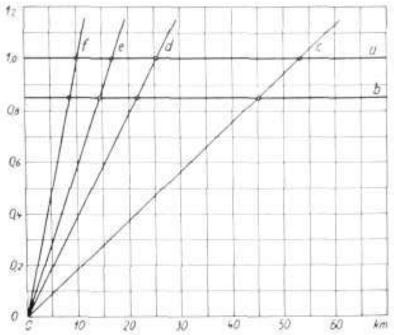

Fig. 3 X 4378

Relative costs of carrier telephone channel plants using different types of transmission lines as a function of the line distance

a	power line, two phase transmission
b	power line, single phase transmission
c	capitalized value of a rented line
d	open wire line
e	*overhead cable*
f	earth cable

deflection of this instrument will then be a function of the impulse frequency and thus also of the transmitted measuring value. For remote indication and control the impulses are generally transmitted according to a certain code.

The terminal equipments of these remote measuring and control systems collaborating with the carrier frequency systems of the LM Ericsson are manufactured by the Allmänna Svenska Elektriska AB (ASEA) and will not be subject to any description in this paper.[1]

Comparison between Different Kinds of Transmission Circuits

Overhead lines of bare copper wire, overhead or earth-cables and power lines may be used for the transmission of the different kinds of signals.

Often the overhead copper wire circuits are subject to functional disturbances caused by storms or bad weather and therefore they are more exposed to perturbations than the other kinds of circuits. The cable circuits are the most reliable but at the same time also the most expensive. The stable construction of the power lines and their good insulation contribute to reliability of transmission when used as signal communication circuits.

In all these types of circuits, several channels for different signals may be arranged on each pair of wires by using different frequencies as carriers of the signals in a *carrier frequency system*. At the terminal stations, the different channels are separated by means of filters. Overhead copper wire circuits or cable circuits may be combined to form more channels than the number of original pairs by means of *bridge circuits*. Thus phantomizing renders possible a third circuit over two pairs. By means of duplex connections, impulses may be transmitted at the same time in both directions on one pair etc. For power lines the carrier frequency systems offer the only method of obtaining more channels. By using a carrier frequency channel for several different simultaneous communications, the costs per single communication with such carrier equipments may be reduced. The initial cost for establishment of the first communication over a certain line is of necessity rather high but, on the other hand, additional costs for further communications are quite low. Generally the first need is that of a telephone channel. With the equipment for this up to three remote metering or control channels in each direction may be obtained at the same time as the telephone conversation. If further remote metering channels are required, a new carrier channel must be added. Relatively the additional cost for channel number 4 means an appreciable jump, see Fig. 2, but the extra expense for subsequent channels is low. The diagram shows carrier frequency communications on a 70 kV line with two derivations and using two of the phases for the transmission.

A comparison of the costs between a telephone channel on this power line and telephone transmission on other kinds of circuits is made in Fig. 3. The cost of establishment of the telephone channel including all basic equipment is with the conditions stated not dependent on the distance and has for two-phase transmission been made equal to unity. With carrier frequency transmission between one of the phases and earth the relative cost will be about 0.85. This and all other costs are based on the Swedish price level in 1946. For the rented circuit the annual rent has been capitalized and added to the entrance fee. The costs for pole erection for the overhead copper line, for the overhead cable with its suspension and the costs for the laying of the underground cable are all included.

The diagram shows that the carrier telephone on the power line is profitable for distances exceeding 53, 25, 17 and 10 km in comparison with a rented circuit, an erected overhead copper circuit, an overhead cable circuit and an underground cable circuit respectively. The corresponding economical distances

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[1] See *Hecht, U:* Remote metering and control in power practice. Teknisk Tidskrift 1945 No 48, pp. 1319—1330.

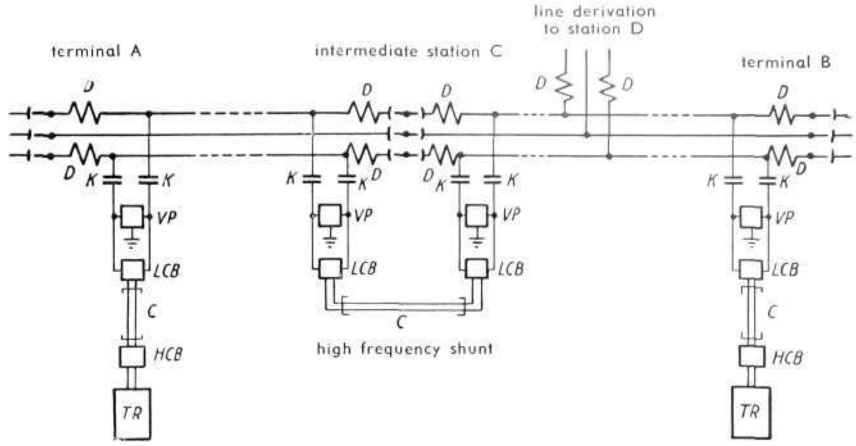


Fig. 4 X 6143
Principle diagram of carrier frequency transmission on power lines

C	high frequency cable
D	high frequency choke coil
HCB	matching transformer
K	coupling condenser
LCB	line connecting filter
TR	carrier frequency equipment
VP	voltage protecting device

for single-phase transmission are 45, 22, 14 and 8 km respectively. Thus the rented circuit is the cheapest for short distances. Renting, however, is generally arranged with a short time for giving notice and the circuit is very often an overhead circuit of bare copper wires with all the disadvantages this involves; a cable circuit commands a considerably higher rent. Moreover, the additional costs for metering and control channels are appreciably greater than by the carrier frequency system. With three remote metering channels in one direction, the economical distances of the carrier frequency channel are about 27 and 23 km respectively. Other circuits also represent greater additional costs than does the carrier channel on the power line. Thus carrier frequency communications are economical even for short distances, at least if the power line does not have too many derivations and sectioning points on the stretch in question.

The Principle of Design of the Carrier Frequency Communication Circuit

On account of the power current frequency being of the same order of value as the signal frequencies, generally 50 c/s, it would be impossible to separate the high tension from the signal voltages, if the signals should be transmitted directly using the low frequencies of their own. Therefore, it is necessary to transmit the signals on the power line within a much higher frequency range. The task of the carrier frequency equipment therefore consists in producing in the transmitter this displacement in the frequency range, restoring in the receiver the signals to their own frequency range and reproducing them with their original character. The great distance between the power current frequency and the carrier frequencies used for the signals makes it very simple to separate them from one another by means of filters.

The principle of the carrier frequency communication circuit design between two stations *A* and *B* is shown in Fig. 4. The carrier frequency equipment consisting of transmitter and receiver is normally placed in the main building of the station and is connected to the line connecting filter device in the high tension switching frame by means of a special high frequency cable. The connection to the power line is done by coupling condensers, which give unimpeded transit in collaboration with the above-mentioned filter device to all the high frequency tensions transmitted but prevent the high power voltage from entering the signal equipment. Instead of condensers, aerials were formerly used as coupling devices suspended under the power line. However the efficiency of this arrangement was bad and long distances could not be covered in this way.

To protect the signal equipment against voltage waves and other overvoltages, which may occur for instance on breakdown of the coupling condensers, there is a voltage protecting device connected between the condensers and the line filter device

The high frequency tensions must be forced to follow the line between the carrier frequency stations and hindered from passing over to other parts of the high tension network, where high frequency energy would be destroyed and of no use, where high frequency tensions of certain frequency values would be absorbed on account of reflexions and where other carrier frequency communications would be disturbed by cross-talk. Therefore the communication path is separated from the remaining network by means of choke coils, which are mounted in the line between the tappings to the coupling condensers and the switching frames of the terminal stations and also in all derivations of the line between the terminal stations. These choke coils have a high impedance within the high frequency bands but a very low impedance for the frequency of the power current.

In an intermediate station *C*, where the line may be divided into two sections but the carrier communication circuit must nevertheless pass unhindered, a high frequency bridge or shunt will be installed. This bridge or shunt consists of line connecting filter devices connected to one another via a high frequency cable and to the two line sections by means of coupling condensers.

The Fundamental Principles of the Carrier Frequency Transmission

The displacement of the signal frequencies up to the higher frequency range is brought about by making a high frequency tension vary one of its properties, e. g., amplitude, frequency or phase angle, in time with the signal frequency, i. e. the high frequency tension is modulated by the signal tension. Of the three methods of modulation the variation of the amplitude, i. e., amplitude modulation, is used most generally by carrier frequency systems for power lines. The frequency modulation and phase modulation methods may give the transmission greater freedom from noise disturbances but only if the carrier channels are given broader frequency bands than is possible with the rather limited high frequency range at disposal from a technical point of view.

The signal transmission of an amplitude modulated channel is shown in diagram by Fig. 5 a. The modulator of the transmitter is fed with the voice frequency signal tension of 1000 c/s together with a high frequency tension of 100 kc/s. The modulator comprises elements having the property that the input tension and the output current are not proportional to each other but have a not linear ratio. Therefore the modulator produces new frequencies consisting of different combinations of the fundamental frequencies and the harmonics of the input tensions. Among these combinations the sum and the

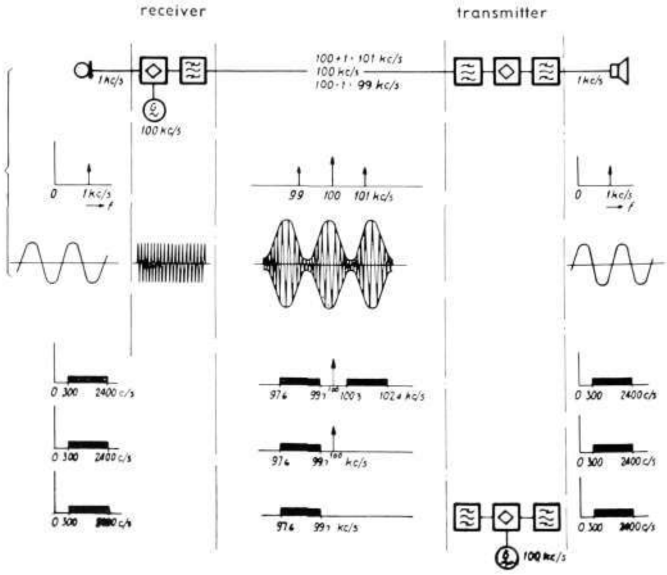


Fig. 5 X 6203

Principle diagram of amplitude modulation

- a general principle of amplitude modulation
- b transmission of carrier frequency with higher and lower side bands
- c transmission of carrier frequency and lower side band
- d transmission of lower side band only and demodulation by addition of the carrier frequency in the receiver station

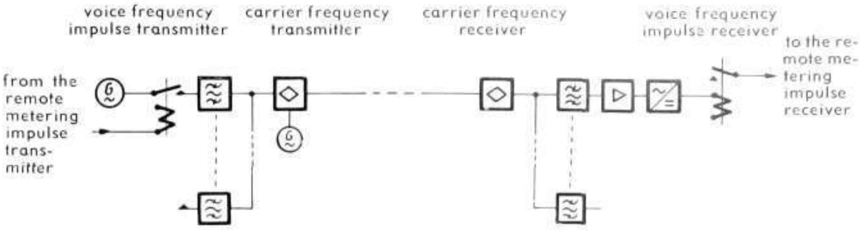

voice frequency impulse transmitter
carrier frequency transmitter
carrier frequency receiver
voice frequency impulse receiver
from the remote metering impulse transmitter
to the remote metering impulse receiver
X 5659

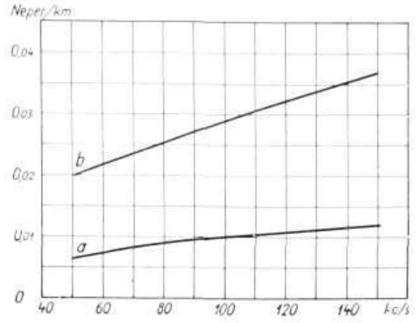
Fig. 6
Voice frequency impulse channel for remote metering and control

difference, 101 and 99 kc/s, of the original frequencies are the useful side frequencies. These side frequencies together with the original frequency, 100 kc/s, *the carrier frequency*, cause the high frequency amplitude to vary in such a manner that its envelope reproduces the original low signal frequency. The ratio between the sum of the tensions of these side frequencies and the tension of the carrier frequency is called the degree of modulation and is generally evaluated in percent. Thus at a modulation degree of 100 percent the tension of the modulated carrier frequency varies between zero and double the value of the tension of the unmodulated carrier frequency.

After modulation, the characteristic properties of the signal, i. e., its frequency and amplitude, have been transferred to the two side frequencies. The frequency of the signal determines the distance from the side frequencies to the carrier frequency. The amplitude of the signal determines the amplitude of the tension of the side frequencies and thus the degree of modulation of the transmission. If the frequency of the signal varies within the cut-off frequencies of a frequency band the corresponding side frequency bands produced in a higher frequency range must be transmitted to the receiver station. Thus, in a telephone channel with the carrier frequency 100 kc/s, the speech or voice frequency band 300—2400 c/s gives the side bands 97,6—99,7 and 100,3—102,4 kc/s as in Fig. 5 b. These side bands are fed through a band pass filter behind the modulator and transmitted on the line along with the carrier frequency. In the receiver this mixture of frequencies passes a demodulator which works in the same way as the modulator in the transmitter. Thus among the frequencies produced by the demodulator will also be found the original signal frequency, which is produced as the difference between the side frequencies and the carrier frequency. The signal tension is taken out through a band pass filter which impedes all other combination frequencies.

Since each side band has all the properties that characterize the original signals it is sufficient if only one of the side bands is transmitted to the receiver, as in Fig. 5 c. Nor need the carrier frequency necessarily be transmitted but it may be produced in the receiver by a local oscillator and fed to the demodulator as in Fig. 5 d. This local oscillator must be very stable in frequency; a difference between its frequency and the untransmitted carrier frequency of the transmitter of more than 20 c/s produces inadmissible distortion in the receiver of the telephone channel. Such single side band systems have attained great importance since they occupy less frequency range than other systems. Moreover the freedom from noise disturbances of the receiver is greater than in the double side band system, because there is received a noise frequency band only half as broad as in the double side band system. In the single side band system with the carrier frequency not transmitted the whole transmission power is put into the side band, which alone represents the signal. By this the ratio between the received signal tension and the noise tension is further augmented. The freedom from noise disturbances of such a transmission will therefore approach that of the frequency modulated systems.

The transmission of the carrier frequency can nevertheless be well justified by other reasons. Thus the carrier frequency can be used for the automatic regulation of the amplification, i. e. the volume control of the receiver, for transmission of the impulses of the selective line protection device etc. Therefore the carrier frequency systems of LM Ericsson are designed for single side band transmission but with a faintly transmitted carrier frequency tension.



Fip. 7 X 4379
Line attenuation of a 100 kV power line

a dry weather
b hoar-frost

Hereby the degree of modulation of the transmitter is considerably higher than 100 percent; in the receiver the modulation degree is reduced by selective amplification of the received carrier frequency tension. In this way also the above-mentioned difficulties of synchronizing the two carrier frequency oscillators of the transmitter station and the receiver station are avoided.

The same line may be equipped with several carrier frequency channels if only these are given different high frequency bands, which are separated from each other in the band pass filters of the respective receivers. In similar way several different remote metering and control signals may be simultaneously transmitted in a single carrier frequency channel by modulation of different voice frequencies. In a voice frequency impulse channel such as is shown by the diagram of Fig. 6, the voice frequency tension produced in a valve oscillator, is chopped by a transmitter relay in time with the D.C. impulses from the remote control transmitter. The voice frequency impulses are built up by the voice frequency serving as carrier frequency and the side frequency spectra placed symmetrically around it. The band pass filter behind the relay cuts off the frequency spectrum to a width which is about double the highest impulse frequency in order to avoid disturbance of the neighbouring voice frequency impulse channels. Only the side frequencies which correspond to the fundamental frequency of the impulsing need in fact be transmitted.

The voice frequencies of the different impulse transmitters will then together modulate the carrier frequency transmitter. In the demodulator of the carrier frequency receiver the voice frequencies are restored and thereafter conducted by voice frequency band pass filters to their respective voice frequency impulse receivers where they are rectified to D.C. impulses. These actuate the receiving relay which transmits the impulses to the remote control receiver.

The voice frequencies may be transmitted by a carrier frequency channel especially meant for remote metering and control or by the same channel as is used by a telephone communication circuit. In the latter case the voice frequency impulse channels are placed either below the lowest frequency of the speech band, 300 c/s, as sub-audio channels or above 2400 c/s as superimposed channels.

As shown by the frequency scheme of Fig. 1, the high frequency range which may be available for the carrier frequency systems for power lines comprises frequencies between 50 and 150 kc/s. In certain cases, however, lower frequencies than 50 kc/s may also be used. Nevertheless, in those cases the choke coils and the coupling condensers must be designed with higher inductance and capacitance respectively than normally and will therefore have larger di-

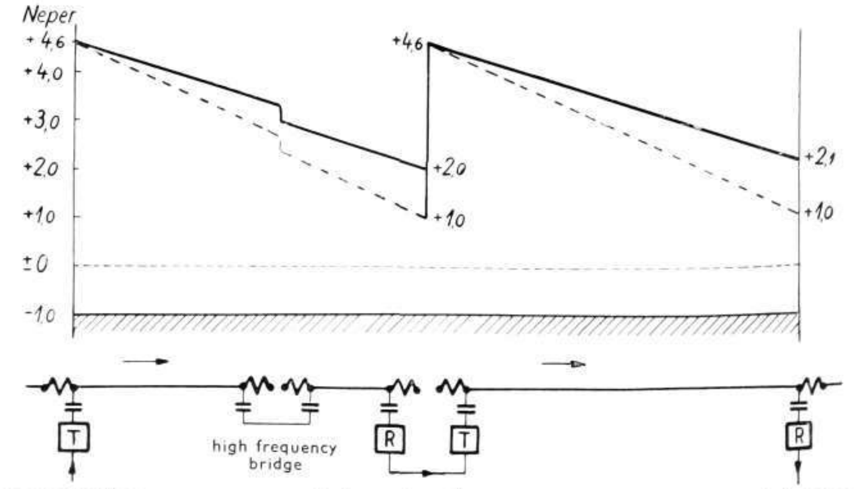


Fig. 8 X 6174
Level diagram of a carrier frequency communication

T transmitter
R receiver

—— dry weather
- - - wet weather
▨ noise level

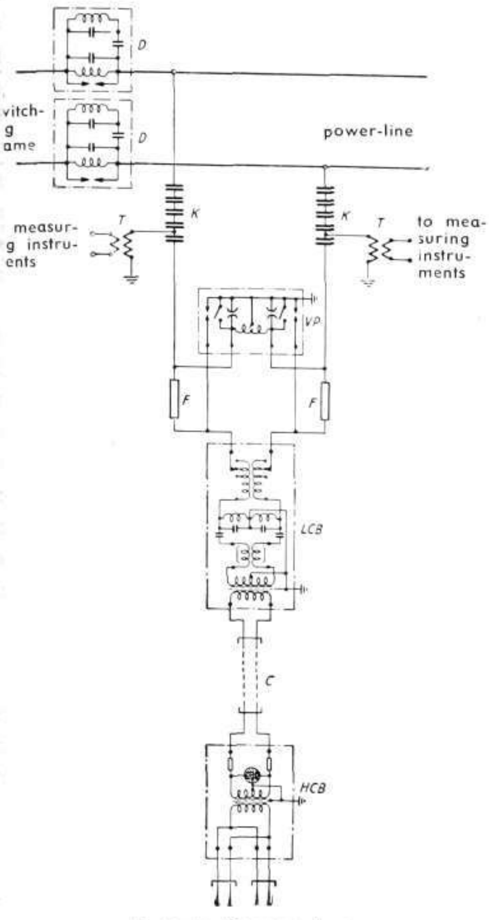


Fig. 9 X 4381

Principle diagram of a line connecting device of a terminal station

C	high frequency cable
D	high frequency choke coil
F	high tension fuse
HCB	matching transformer
K	coupling condenser
LCB	line connecting filter
T	measuring transformer
VP	voltage protecting device

mensions making them grow more expensive. The upper limit of the frequency range is set by the broadcasting frequency range. Higher frequencies than 150 kc/s would enter this range, involving the risk of mutual disturbance.

The Properties of the Lines

The attenuation of the power lines causes the high frequency power to diminish along the line from the transmitter end towards the receiver end according to an exponential function. The natural logarithm of the ratio between the tensions in two points of the line gives the attenuation between the two points, when the unit is neper. Thus if the received tension is one half of the transmitted one, it means, that the line has the attenuation log. nat. $2 = 0.7$ neper.

The attenuation of the line is made up of the resistance attenuation and the leakage attenuation. Thanks of the good insulation of the power line the leakage is negligeable in dry weather and the attenuation is mainly determined by the resistance of the wires. At high frequencies this is appreciably greater than the D.C. resistance owing to the fact that the high frequency current under the influence of the electric field within and around the conductor is forced to pass through a thin shell close to the surface of the conductor only. Thus with a copper conductor at 100 kc/s the penetration depth of the current is 0.2 mm only compared with about 10 mm at 50 c/s. This displacement of the current causes the attenuation to grow approximately with the square root of the frequency. In the formula for the resistance attenuation per km

$$\beta_r = \frac{1}{2} \frac{r}{Z}$$

there is comprised not only the resistance r per km but also the characteristical or wave impedance Z of the line

$$Z = \sqrt{\frac{l}{c}}$$

where l and c are the inductance and the capacitance per km of the line. These on the other hand are dependent on the diameter of the conductor, the distance between the phases and the general construction of the line.

In wet weather the leakage attenuation will have be added

$$\beta_g = \frac{1}{2} gZ$$

where g is the conductance pr km between the conductors. The leakage attenuation grows about proportionally with the frequency. The additional attenuation will be extremely great for hoar-frost and sleet when the dielectric losses in the ice-layer round the conductor may augment the attenuation up to 3 or 5 times the normal value.

The attenuation of a certain 100 kV line of which two phases are used for the transmission is shown as a function of the frequency in Fig. 7. As a useful mean value of the attenuation under dry weather conditions at about 100 kc/s, 1 neper per 100 km may be given for lines of this kind. A line for 200 kV has generally larger conductor diameter and thus less attenuation, say about 0.5 neper per 100 km. Often the attenuation curve has not such an even course as in Fig. 7, but the attenuation may have pronounced wave-crests due upon reflexions and frequency-selective couplings to other phases and neighbouring lines. It is often therefore difficult to calculate the attenuation of the line in advance.

In some circuits the high frequency equipment is connected between one of the phases of the power line and earth. On account of the great earth resistance against high frequencies, the other phases take over the earth's task as return conductor a short way from the coupling points by means of inductive and capacitive coupling between the line and earth. The coupling losses at these

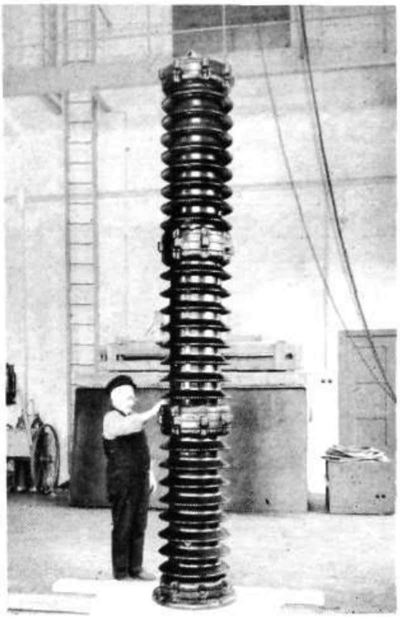


Fig. 10 X 4496
Coupling condenser for 220 kW

places bring about an additional attenuation, which for the two terminal stations of a communication will amount to about 1 neper and thus in case of single phase transmission has to be added to the normal attenuation of the line. Moreover, this additional attenuation must be added also at every point where a high frequency bridge is arranged. Generally the other phases not used for the transmission are not equipped with choke coils. In these phases currents induced by the active phase may therefore go unimpeded to the switching frames thus causing further losses. Moreover with single phase transmission the active phase acts as an antenna and through this the communication may cause disturbances in radio receivers of low selectivity in the neighbourhood of the line. On the other hand radio telegraphy on long waves may disturb the carrier current communications.

The risk of disturbances is much less with two-phase transmission on account of relatively good symmetry to earth of the two phases. The communication grows more reliable with two-phase transmission as regards the possibility of break of conductors. Should one of the phases happen to break, the transmission of the signals would generally not be disturbed. Often the communications may be maintained even with three-phase short-earthing. On account of electro-magnetical coupling between the line loops on each side, the high frequency energy will be conducted over the faulty place. In spite of the merits of the two-phase transmission, the economical points of view are often decisive for the single-phase transmission because the latter necessitates only half the number of choke coils and coupling condensers. For long and important communications two-phase transmission is always used.

The characteristic or wave impedance is practically ohmic and about 600—800 ohms between two phases. Between one phase and earth it has the value 300—400 ohms. High voltage cables may only be used over shorter distances for carrier frequency transmission on account of their great attenuation, about 0.1 neper per km. Their characteristic impedance is about 50—100 ohms.

The high frequency disturbances on power lines are generally very strong. They are caused by voltage waves produced by sudden changes of load or switchings in the power network, or originate in atmospherical discharges, corona phenomena or the like. In rainy and wet weather they are strongly pronounced on account of intermittent leakage currents via the insulators and of the momentary changes of the electrical field which occur when the raindrops pass in the vicinity of the line conductors. The disturbances caused by the corona increase with the working voltage and a 220 kV line has thus a considerably higher noise level than a line with lower voltage. Generally a new line has more disturbances due to the corona on account of the uneven surfaces of the conductors. These irregularities will however gradually disappear by burning.

The frequencies of the disturbances are spread over the whole frequency range concerned and thus the disturbance tensions cannot be prevented from entering the carrier frequency receivers, where they will be amplified along with the signal. Thus it is necessary that the level of the signals is made considerable

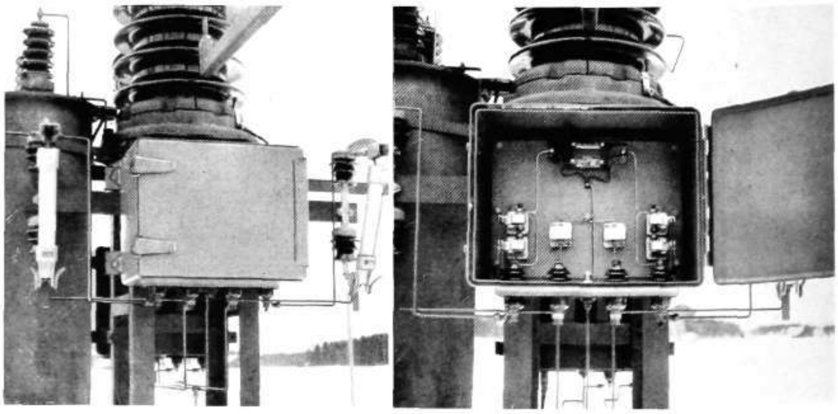


Fig. 11 X 6152
Voltage protecting device with a high tension fuse on each side

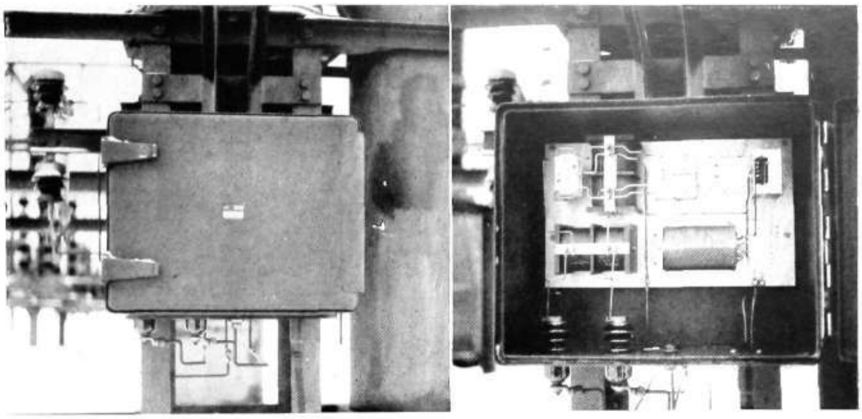


Fig. 12
Line connecting filter
X 6153

higher than the noise level. These levels are measured in nepers above or below a given zero level, normally 1 mW in the impedance 600 ohms, and are defined as half the natural logarithm of the ratio between the power in question and the power representing the zero level. Thus positive or negative level indicates that the power is greater or smaller than the zero level power.

A good survey of the levels in a communication is given by the level diagram in Fig. 8. At the beginning of the line the output level of the transmitter has to be relatively high in order to let the level of the received signal be sufficiently high, i. e. at least about two neper above the noise level in that point. The power of the transmitter is thus normally of the magnitude of 10 W, corresponding to the level $\frac{1}{2}$ log. nat. $\frac{10}{0.001} = + 4.6$ nepers. From the transmitter end of the line the level diminishes on account of the attenuation of the line. This is represented in the diagram by a straight line with greater or less inclination according to the weather. In the high frequency bridge the signal level falls 0.3 nepers, a value which is equivalent to the attenuation of the bridge and thus the level line is broken in this point. The noise level for wet weather is in this case supposed to be — 1 neper and the high frequency level may therefore not fall more than to about + 1 neper if the noise disturbances is not to be too troublesome in the receiver. In the dividing points between the different sections, intermediate repeaters are inserted or the sections are terminated by complete terminal equipments. Thus the level of the new section will in every case be augmented.

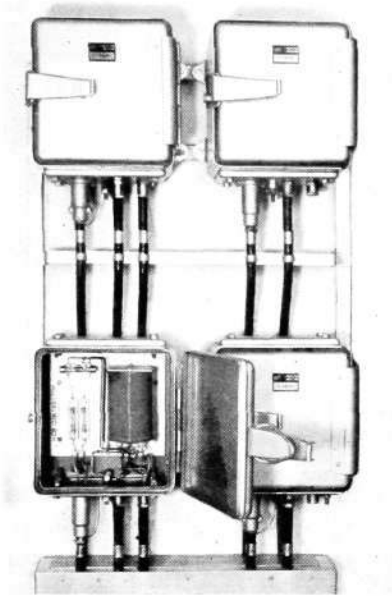


Fig. 13
Matching transformers
in boxes for four lines
X 4387

By means of intermediate repeaters the level may not as a rule be augmented by more than about 2.5 nepers. The unchoked phases of the power line and other parallell lines represent reaction paths from the output side to the input side of the repeater and thus the repeater begins to howl at a sufficiently high amplification. It is therefore often more advisable for every line section to have its own separate carrier frequency equipment. By using different high frequency bands for the neighbouring sections howling by reaction and cross-talk between the channels is avoided and normal transmission level may be obtained.

By the modulation, the transmitter power is distributed to the side frequencies. The level of each of these side bands must be at a satisfactory distance from the noise level. The number of voice frequency impulse channels in a carrier frequency channel is therefore limited for a given range by the noise disturbances. The noise level lies at about — 4 nepers on lines for 100 kV and on lines for 220 kV at about — 2 nepers.

With knowledge of the transmission level, modulation degree, line attenuation and noise level, the maximum range of a communication may be calculated. The range of a telephone channel with superimposed voice frequency channels for remote metering and control without intermediate repeaters is about 300—400 km on a 220 kV line. About the same range will be attained on power lines with lower working voltage; the lower noise level is counterbalanced by the greater attenuation of the line.

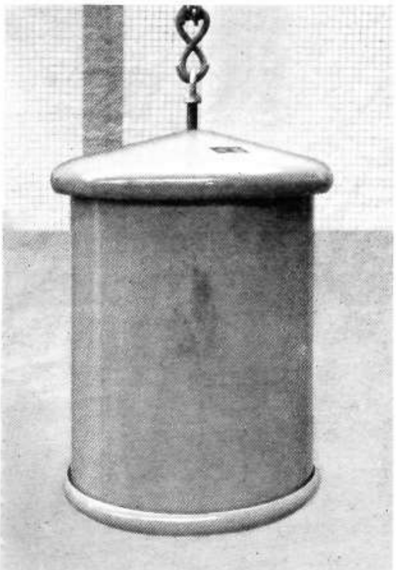


Fig. 14
High frequency choke coil
X 4388

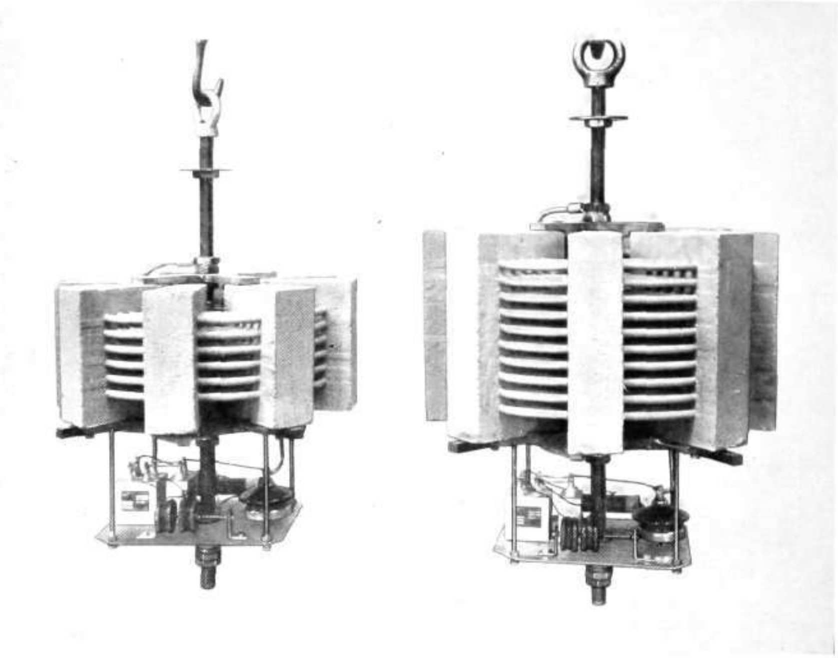


Fig. 15 X 6154

High frequency choke coils

with dust cover removed; left: 250 A wkg currents; right: 500 A wkg current

Line Connecting Equipment

The connection of the different apparatus included in the line connecting equipment is shown in the detailed diagram of Fig. 9.

The Coupling Condensers K are made with capacities of (1000 to) 3000—7000 pF, if they are used exclusively for carrier frequency transmission. Nevertheless condensers for voltage protection with considerably greater capacitance values may be used to advantage simultaneously as coupling condensers if only the bottom tapping of the condensers, normally earth-connected, is insulated from earth. By connection of a voltage transformer to another suitable tapping of the condenser it may also be used as voltage dividing capacitor for measuring the voltage of the line. The costs of establishment of the carrier frequency equipment will thereby be considerably reduced. The condenser shown in Fig. 10 is such a protecting condenser, manufactured by Sieverts Kabelverk and designed for a 220 kV line. The capacity is 9500 pF. The condenser is normally charged with the phase voltage of the line but has to stand the whole main voltage in case of earth faults and is therefore tested for 450 kV. It is built up in three sections which are constructed of a number of elements connected in series and are piled on one another. The coupling condensers may also be built for suspended mounting.

The power frequency charging current of the coupling condenser is conducted to earth by the *voltage protecting device VP* of ASEA:s make, Fig. 11, through a choke coil with low impedance against the power frequency. The choke coil is directly coupled in parallel with a large spark gap and via fuses with a small spark gap, these fuses igniting for overvoltages and conduct these to earth. For stronger currents the fuses will blow and separate the high frequency equipment from the power line. The coupling condensers may be directly earthed by means of earthing knives built into the voltage protecting device.

The Line Connecting Filter LCB, Fig. 12, is designed as a band pass filter for the whole high frequency range. The coupling condensers are included as filter elements. The filter coil nearest the line has tappings for the matching of the filter to the capacitance of the condensers. In this way a good matching to the characteristic impedance of the power line is obtained. The matching transformer between the filter and the high frequency cable is given extremely high insulation.

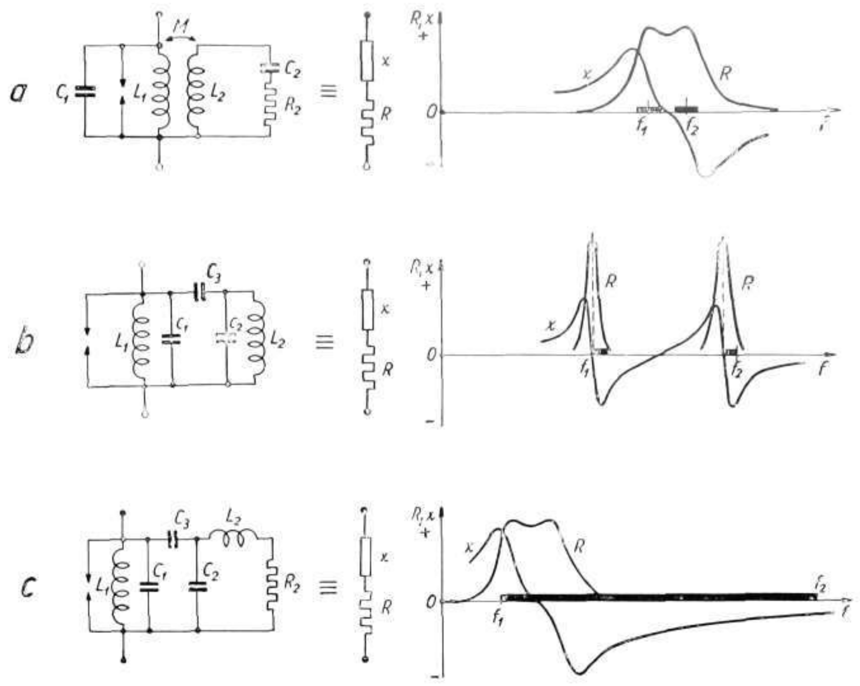


Fig. 16
Principle diagrams of choke coils

X 6141

- a choke coil with vicinal bands
- b choke coil with remote bands
- c all frequency choke coil

For *High Frequency Cable* a two-wire telephone cable with thick conductors is normally used. Only for long sections is a coaxial cable necessary. The cable is led to the building where the carrier frequency equipment is located and is terminated by a *Matching Transformer HCB*, Fig. 13, built into a standard cable box together with fuses and a gaseous discharge lamp with earthed mid-electrode, all serving as additional voltage protection for the plant.

The High Frequency Choke Coil D, which is inserted in the power line towards the switchgear and in line derivations, consists of an inductance coil with relatively large external dimensions and of some tuning elements. It is passed by the power current of low frequency. The choke coil is designed to stand the heat of the losses of the normal power current and the mechanical strains which the great short-circuit currents of the power network might bring about. As a voltage protection, a spark gap is connected directly across the main inductance coil. In the choke coils in Fig. 14 and 15, manufactured by ASEA, the tuning elements are placed under the main coil and are thus easily accessible and at the same time protected against overheating. Normally the choke coil is designed for two high frequency bands. If more bands have to be impeded, several choke coils are connected into series or in special cases broad band choke coils are used.

The two band choke coils are tuned to one of two circuits depending upon the frequency distance between the two high frequency bands. With bands fairly close, especially in older systems, the circuit of Fig. 16 a is used consisting of two resonance circuits inductively coupled to one another. By augmenting the series resistance of the secondary circuit a fairly constant impedance and mainly resistive is obtained within the choking frequency range. The choke effect is therefore about the same for the carrier frequency and the side band as distinguished from choke coils of still older types where the choke impedance falls off rapidly at both sides of the carrier frequency. With these older choke circuits the quality of the transmission suffers by the fact that the higher side frequencies are attenuated more than the lower ones. There is also risk of further distortion by series resonance phenomena within the choking range between the inductive impedance and the impedance of the power transformers behind the choke coils, which is normally capacitive at high frequencies. Adverse effect of such resonance phenomena is hindered in the circuit shown thanks of the ohmical part of the impedance.

In modern systems with single side band transmission and usually with a relatively large frequency distance between the two transmission bands the circuit of Fig. 16 b is used. The two resonance circuits are here capacitively coupled to one another. On account of low losses in the resonance circuits the resistance diminishes very sharply for frequencies by the side of the resonance frequencies. Instead of the resistance the reactance is here used for the choke effect and by placing the transmission bands within the capacitive reactance range, there is avoided with this coupling the occurrence of frequency absorbing series resonance phenomena within the choking range.

The broad band choke coils shown in Fig. 16 c, designed for choking a larger frequency range, contain coils with considerably larger inductance than the normal two-band choke coils. They are therefore economical only when a large number of high frequency channels are transmitted on the power line. The coupling between the resonant circuits is capacitive. By augmenting the series resistance in the secondary circuit a resistant choking range is obtained at the lower frequencies. The higher part of the choking band is brought about by the capacitive reactance of the choke coils.
Protecting condensers connected along the line are prevented from conducting the high frequency tensions to earth by means of choke coils in series with the condensers. These choke coils need not be designed for such large currents and thus their dimensions are small in spite of their large inductance. They are designed for choking the entire high frequency range. The same may be said of the portable choke coils through which the line conductors must be earthed while the line is undergoing repair. The high frequency communications have to continue in spite of this earthing.

Carrier Frequency Equipment

The main parts of the carrier frequency equipment consist of the high frequency transmitter and the high frequency receiver, which are connected to the power line via the line connecting filter device, and the low frequency equipment through which the low frequency signals are conducted to the above high frequency equipment. Therefore the low frequency equipment has to be designed in a variety of ways according to the caracter of the signals and to the signal circuits which are connected to the carrier frequency equipment. Thus besides the high frequency part including transmitter and receiver for the two speech directions the terminal equipment of a telephone communication contains a fork equipment for the connection of a two-wire telephone circuit. In certain cases a four-wire equipment is included for the connection of a four-wire circuit for telephone transmission to and from the carrier frequency equipment on two pairs of wires, one pair for each speech direction. The LM Ericsson high frequency telephone channel can transmit together with the speech three separate remote metering or control signals in each direction by means of superimposed voice frequency impulse channels. To the fork equipment in such terminals also voice frequency impulse transmitters and receivers are added. Any further requirement of remote metering and

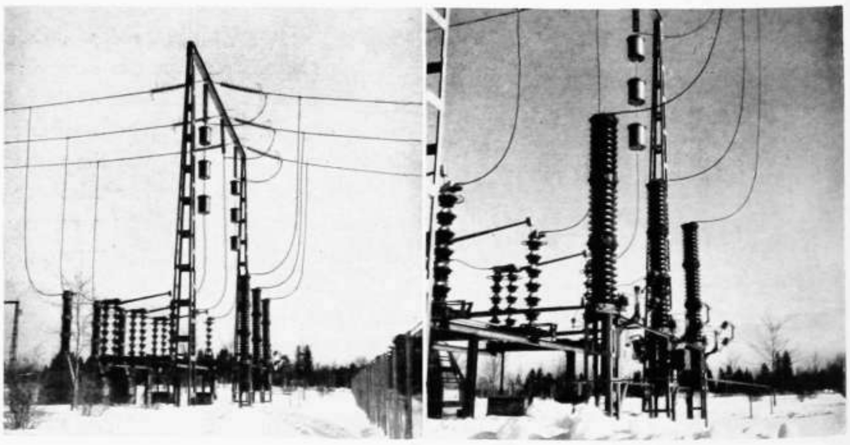


Fig. 17 X 6177
Line connecting equipment of a 220 kV switching frame

for three high frequency communications on the same power line

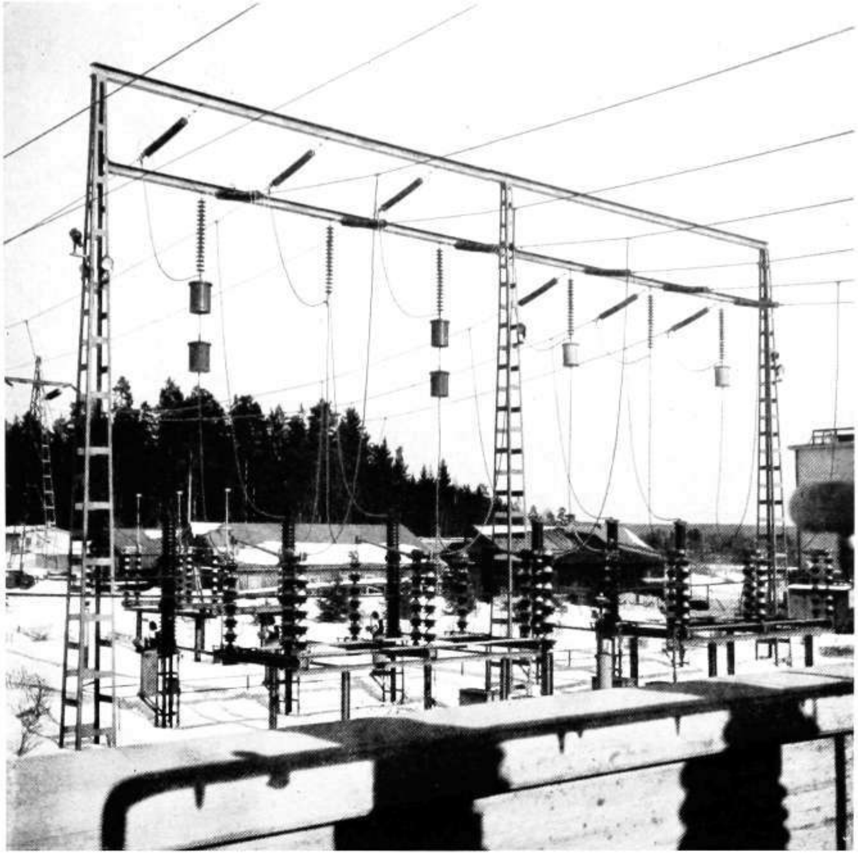


Fig. 18 X 6176

Line connecting equipments

for two lines; both lines transmit speech. The left line is also used for remote control transmission using a separate high frequency channel

control communications in one or both directions necessitates the addition of new carrier frequency equipments which contain high frequency and voice frequency transmitters in the transmitter station and the corresponding receivers in the receiver station.

LM Ericsson manufactures standardized unit panels which are assembled into bays to form equipments with the above mentioned properties. Thus there is a telephone bay for a telephone channel with superimposed voice frequency impulse channels and a metering bay with impulse channels for remote metering and control only. Often more complicated transmission problems are also met with, which necessitate special equipment. In every such case, however, it is easy, thanks to the flexible method of construction, to complete the more usual bays by a suitable apparatus taken from another of the manufacturing branches of LM Ericsson or to assemble the necessary apparatus into special bays, thus forming the requisite equipment.

The Principles of Function of the Carrier Frequency Equipment

The terminal equipment of a two-way carrier frequency channel for telephone transmission uses different high frequency bands with different carrier frequencies in the transmitting and receiving directions. The distance between the carrier frequencies is 30 kc/s. On account of the fact that only one of the high frequency side bands is transmitted, each of the directions of transmission requires a frequency band of 3 kc/s only.

The modulation method, as described above and shown in Fig. 5 a, gives high frequency side bands which lie too close together to be separated from each other in normal high frequency band filters. Crystal filters might be employed but would be very expensive and therefore another method is used to suppress the side band not transmitted namely by double modulation in the carrier

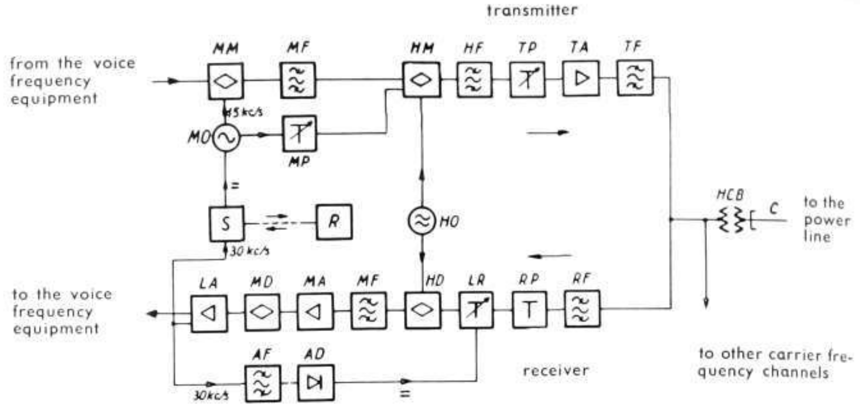


Fig. 19 X 6151

Principle diagram of a terminal equipment for a two-directional carrier frequency communication

AD	rectifier and pilot amplifier
AF	filter for the automatic level regulation
C	high frequency cable
HCB	matching transformer
HD	high frequency demodulator
HF	high frequency band filter
HM	high frequency modulator
HO	high frequency oscillator
LA	low frequency amplifier
LR	automatic level regulator
MA	intermediate frequency amplifier
MD	intermediate frequency demodulator
MF	intermediate frequency band filter
MM	intermediate frequency modulator
MO	intermediate frequency oscillator
MP	control attenuator for the modulation degree
R	relay equipment for the selective line protection
RF	receiver band filter
RP	attenuator for the received level
S	additional equipment for the selective line protection
TA	transmitter amplifier
TF	transmitter band filter
TP	control attenuator for the transmission level

frequency transmitter. After the first modulation in a lower frequency range the relative frequency distance between the two side bands is large enough to allow of one of the side bands being taken out by filters while the other is suppressed.

The design principle of the high frequency part of a two-way communication is shown in Fig. 19 which is in the following account supposed to be used for telephone transmission. The voice frequency tensions from the fork equipment are supplied to the first modulator of the transmitter, i. e. the intermediate frequency modulator *MM*, where they modulate the intermediate frequency 15 kc/s, which is produced in an oscillator *MO*. The band filter *MF* permits only the lower of the two side bands produced by the modulation to pass. The low frequency speech band 300—2400 c/s is thus displaced behind the filter to the intermediate frequency band 12.6—14.7 kc/s. This band, together with the intermediate frequency from the oscillator *MO*, will then undergo a new modulation in the high frequency modulator *HM*. The degree of modulation, determined by the ratio between the side frequency tension and the tension of the 15 kc/s frequency, is regulated to the correct value by the potentiometer *MP* which controls the tension of 15 kc/s supplied to the modulator. As stated above, the modulation degree is high, totalling about 200 percent, for the sum of the amplitudes of the different transmitted signals. In the modulator *HM* a high frequency tension is modulated which is produced in the oscillator *HO*. In this way two side bands are produced situated 15 kc/s apart on each side of the high frequency. Thanks to the large frequency distance, 30 kc/s between the side bands, the following band filter *HF* can be designed for the passage of one of these side bands only. The result of the double modulation has thus been that only one side band and the carrier frequency are transmitted from the filter *HF*, the latter being the 15 kc/s which is displaced to higher frequencies by the modulation. The tension of the carrier frequency is here smaller than in other transmitters with maximum 100 percent modulation thanks to the high degree of modulation in this case.

In the opposite direction the transmission is done with a frequency band which corresponds as regards frequency with the suppressed high frequency side band of the transmission described above. Therefore the high frequency modulators of the terminal stations use the same frequency for the modulation but their filters *HF* are designed for frequency bands which are 30 kc/s apart from each other. The table below gives a summary of the modulation course of a communication with the carrier frequencies 102 and 132 kc/s in both directions:

Voice frequency band (speech)	300—2400 c/s
On modulation in *MM* there is produced	12.6—14.7 kc/s
	and 15.3—17.4 kc/s
To the *HM* is supplied	12.6—14.7 kc/s
	and 15 kc/s
The high frequency from *HO*	117 kc/s

On modulation in *HM* there is produced 102, 102.3—104.4 kc/s
and 129.6—131.7, 132 kc/s

In the direction *A—B* there is transmitted {
carrier 102 kc/s
Side band 102.3—104.4 kc/s

In the direction *B—A* there is transmitted {
carrier 132 kc/s
Side band 129.6—131.7 kc/s

The modulation course for the direction *A—B* is shown in diagram in Fig. 20 a—d.

The carrier frequency and the side band is delivered to the transmitter amplifier *TA*, the push-pull coupled output stage of which gives the necessary transmission power. The output level is regulated to a suitable value by the potentiometer *TP*. After the amplifier there follows another band filter *TF* with the task of straining off all harmonics of the transmission which might fall into the broadcasting frequency range and thus could disturb radio receivers in the neighbourhood of the power line and partly of hindering the frequencies of the receiver and all other connected channels from entering the transmitter. The modulated carrier frequency is finally conveyed via the matching transformer *HCB* and the high frequency cable on to the power line.

The modulated carrier frequency received from the remote terminal station passes through the receiver band filter *RF*, the attenuator *RP* and the automatic level regulator *LR*. In the high frequency demodulator *HD*, the high frequency band is displaced to the intermediate frequency range by demodulation with the high frequency from the oscillator *HO* and the carrier frequency 15 kc/s and its side band 12.6—14.7 kc/s are taken out through the next filter *MF*. Moreover the filter *MF* contains an equalizing network which augments the amplitude of the carrier frequency in comparison with the side frequencies. The modulation degree will thereby be lower, which diminishes the distortion at the final demodulation to voice frequency in the demodulator *MD*. Before this demodulation, the intermediate frequency tensions are amplified in the amplifier *MA*. The voice frequency tensions pass through an amplifier *LA* on their way to the fork equipment and the telephone instrument. The demodulation progress is summarised in the diagram of Fig. 20 d—f.

In the equipments where the carrier frequencies are not to be transmitted but only the side bands, as per Fig. 5 d, the modulation potentiometer *MP* is regulated to zero and thus no tension at 15 kc/s is supplied to the high frequency modulator. For the demodulation in the receiver a local intermediate frequency is supplied from the oscillator *MO* to the demodulator *MD*. The modulation and demodulation frequencies in the two terminal stations must be equal to give distortionless transmission and thus the oscillators of the respective stations must from time to time be synchronized to each other as distinguished from normal communications with transferred carrier frequency where a small difference in frequency between the two oscillators has no importance because the carrier frequency and the side frequencies always

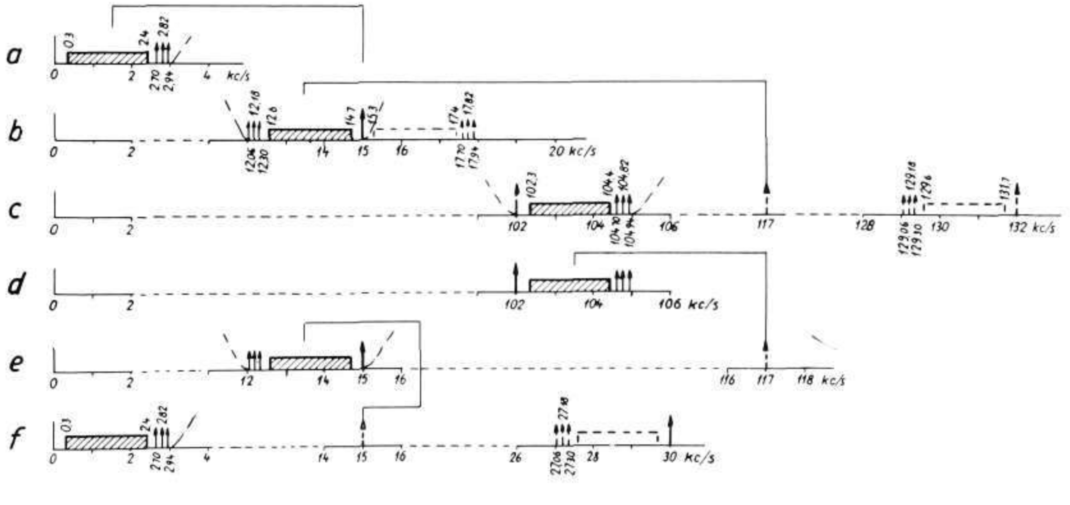


Fig. 20 X 7401

Modulation and demodulation diagram for an unidirectional carrier frequency communication

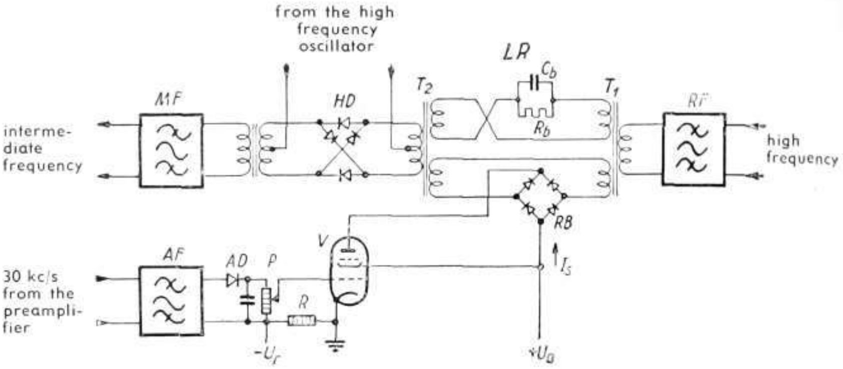
- a low frequency band of the telephone speech and superimposed voice frequencies
- b intermediate frequency band after the first modulation in the transmitter
- c high frequency band after the second modulation in the transmitter
- d carrier frequency with side band on the line
- e intermediate frequency band after the first demodulation in the receiver
- f low frequency band and redoubled intermediate frequency after the second demodulation in the receiver

Only the frequencies and frequency bands drawn with unbroken lines are transmitted

Fig. 21 X 6145

Principle diagram for the automatical level regulation system

AD	rectifier
AF	band filter for 30 kc/s
C_b	balancing condenser
HD	high frequency demodulator
I_s	pilot current
LR	level regulator
MF	intermediate frequency filter
P	potentiometer
R	fixed resistance
R_b	balancing resistance
RB	rectifier bridge
RF	receiver band filter
T_1 T_2	differential transformers
U_a	anode voltage
U_r	constant voltage for the comparison
V	pilot valve



maintain the original frequency distance from each other. For transmission without carrier frequency a different automatic level regulating system is used than when carrier frequency is transmitted. The level regulator *LR* may also be displaced by a manually adjusted potentiometer.

The Automatic Level Regulation System

The high frequency receiver is designed with an automatic level regulation which makes the low frequency signal level received independent of the large variations in attenuation of the line with changes in weather conditions.

On demodulation in the demodulator *MD*, among other frequencies there is also produced the double carrier frequency after having been displaced to the intermediate frequency range, or 30 kc/s as in Fig. 20. The tension of this frequency is used as a pilot tension for the automatic level regulator and it is therefore amplified together with the low frequency signal tensions in the amplifier *LA*, taken out in the following band filter *AF* and rectified in *AD* as per Fig. 19. The rectified current pilots the level regulator *LR* the principle of which is shown more clearly in Fig. 21. The regulator consists of a bridge composed of the two differential transformers T_1 and T_2 which are connected by equal part winding to each other: one way through the resistance R_b and the condenser C_b and the other way through the rectifier bridge *RB*. The windings of the two parts of transformer T_2 are opposite to one another and thus the currents through these two winding parts more or less compensate one another. The tension over the secondary winding of the transformer T_2 will therefore be more and more diminished the more the impedance of the rectifier bridge coincides regarding amplitude and phase angle with that of the balance impedance $R_b C_b$, finally equalling zero when these two impedances become quite equal. The impedance of the rectifier bridge is piloted by the above-mentioned rectified current I_s which passes the bridge diagonally. An increase from a low value of the pilot current through the D.C. diagonal diminishes the impedance of the A.C. diagonal of the bridge and at a certain maximum current the regulator attains balance. The pilot current is produced as the anode current of the valve *V*, on the grid of which the rectified positive pilot tension U_p from the rectifier *AD* is laid as well as a fixed negative tension U_r for the comparison with U_p. On account of the fact that these two tensions are large the resulting differential tension on

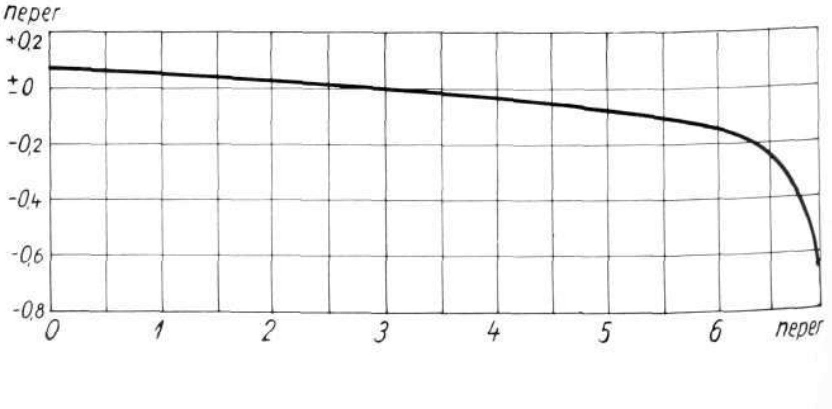


Fig. 22 X 6173

Regulation curve

Received speech level as a function of the line attenuation

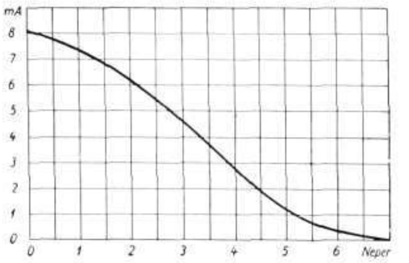


Fig. 23 X 4383
Pilot current through the level regulator as a function of the line attenuation

the grid and thus also the anode current of the valve will vary very sharply even at small variations of the pilot tension.

If now, for instance, the high frequency level received on the line should fall the pilot tension of 30 kc/s will also drop, thus bringing about a decrease of the pilot current through the regulator and less attenuation in the transformer T_2. In this way the pilot tension grows until equilibrium is finally obtained in the regulator. The regulation curve in Fig. 22 shows that with line attenuations of up to 5—6 nepers the variation of the speech level received is not larger than about 0.03 nepers for a variation of 1 neper of the line attenuation and that the range of the equipment is about 6.5 nepers. Nevertheless this large range cannot normally be made use of but it may be employed in exceptional conditions only, for instance in case of line breaks from hoar-frost. The receiver is therefore equipped with a switch by which a suitable attenuation may be disconnected from the attenuator *RP* in such cases.

The current value I_s is a measure of the attenuation of the line and can be read on an instrument of the equipment. The corresponding curve, made up of mean values of a large number of equipments, is shown by Fig. 23.

The circuit of the high frequency modulator is also shown in Fig. 21. This ring-modulator as it is called is constructed of copper oxidule rectifiers and is used for all modulators and demodulators in the system. Regarding the principles see a previous paper.[1]

Filters and Frequency Allocation

The quality of the signal transmission is to a great extent dependent upon the filters of the equipment and thus rigorous demands on these apparatus must be done. Within the transmission band of a filter a certain bottom-attenuation is inevitably to be found on account of the losses in the coils and condensers of which the filter is constructed. The bottom-attenuation ought to be as low as possible in order to avoid the signal tension being wasted and it ought to be nearly equal for all transmitted frequencies within the band. In the choke range, however, the filter must have large attenuation in order to impede unwanted frequencies.

The attenuation of the transmitter and receiver band filters of a high frequency terminal equipment is given as a function of the frequency in Fig. 24. The transmitted carrier frequency is here 102 kc/s. The task of the receiver band filter is to impede the entrance of large tensions of the transmitter to the receiver and cause disturbances. The filter must therefore have very large choke attenuation at the frequency band of the transmitter i. e. 102—105 kc/s. In this case an attenuation of 13 nepers has been measured which means that a disturbing tension has been diminished to $\frac{1}{400000}$ of its original value after

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[1] *Kruse, S* and *Aurell, C-G;* Single Carrier Telephone for Open-Wire Circuits. Ericsson Review 1936 h. 2 pp. 57—58.

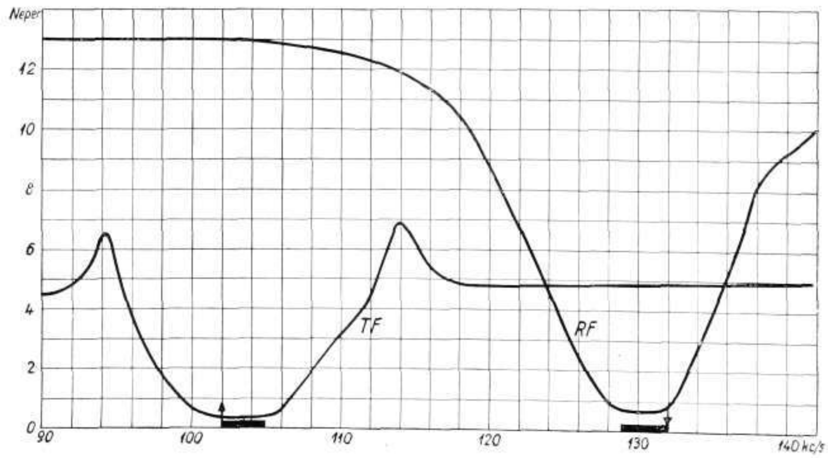


Fig. 24 X 6146
Attenuation curves of the high frequency filters

TF transmitter band filter
RF receiver band filter

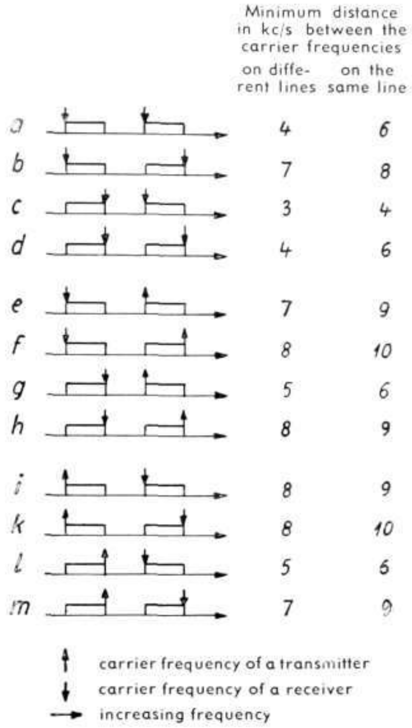

Minimum distance in kc/s between the carrier frequencies
on different lines
on the same line
a 4 6
b 7 8
c 3 4
d 4 6
e 7 9
f 8 10
g 5 6
h 8 9
i 8 9
k 8 10
l 5 6
m 7 9
carrier frequency of a transmitter
carrier frequency of a receiver
increasing frequency

Fig. 25 X 4384

Frequency distance between vicinal high frequency bands in the same station

a—d between receiver bands or between transmitter bands
e—m between a receiver band and a transmitter band

having passed the filter. In the vicinity of its pass band, 129—132 kc/s, the choke attenuation is smaller but here the total attenuation of all other filters of the receiver collaborate to hinder cross-talk from irrelevant channels. The bottom-attenuation of the receiver band filter within the pass band is about 0.6 nepers, which corresponds to a diminution of the tensions of useful frequencies by about 45 percent.

The inductance and capacitance values of the coils and condensers respectively of the filter determine the course of the attenuation curve and thus these values must not change with time. The inductance values must also not be influenced by the current variations in the filter. A coil varying with the current acts as a modulator and can thus destroy the choking ability of the filter by causing combination frequencies which fall within the passband. The transmitter band filter and the first parts of the receiver band filter, which are exposed to the largest high frequency power, contain therefore air-core coils. All other filters have iron-core coils. In all high frequency filters stable mica condensers with low loss coefficient are used. They are manufactured by LM Ericsson.

The accessible high frequency range is limited and it is therefore necessary to allocate the frequency bands of different communications as near one another as possible without the channels disturbing one another. The total selectivity of the high frequency receiver and the receiving part of the low frequency apparatus determines the necessary frequency distance from the adjoining channels within the same station and on parallel lines. Communications on the same power line demand larger internal frequency difference than communications on lines separated by high frequency choke coils, transformers and other switching frame equipment which attenuates the high frequency tensions on their passage from line to line. A receiver demands larger frequency distance from a transmitter on account of the large level difference than from another receiver, because here the signal levels are of about the same value. The transmitter channel bands and the receiver channel bands are therefore if possible allocated to separate transmitter and receiver groups which are free from any bands of the opposite kind. Owing to the large choke attenuation of the filters at irrelevant frequencies the channel bands of LM Ericsson systems may be allocated relatively close to one another as per Fig. 25. A well used frequency range in a great high frequency station is shown in the scheme of Fig. 26. However, this ideal frequency allocation can only very rarely be realized and then only in case of planning a new high frequency network; existing circuits of older construction or of foreign make very often cause trouble in allocation.

The Fork Equipment of the Telephone Circuit

The two line or speech wires from the telephone switchboard of the power station constituting a separate unit and not linked with the carrier frequency equipment are connected to the fork hybrid coil or differential transformer *D* in the fork equipment of the telephone bay as in Fig. 27. The task of the differential transformer is to form an intermediate link between the two wire line and the four wire line represented by the two-directional carrier frequency channel. Thus the transformer transfers the speech currents from the telephone switchboard to the carrier frequency transmitter and from the carrier frequency receiver to the switchboard respectively and during this process prevents the speech currents received from entering the transmitter at too large a level. With an unsatisfactory attenuation between the receiver and the transmitter i. e. across the differential transformer in the both terminal stations, the channel may get into low frequency reaction and howling. This is prevented

Fig. 26 X 7402

Illustration of the frequency allocation in a large high frequency station

R_{1-12} receiver bands
T_{1-12} transmitter band

Transmitters and receivers with the same numbers may be combined to form terminals of two-directional communications

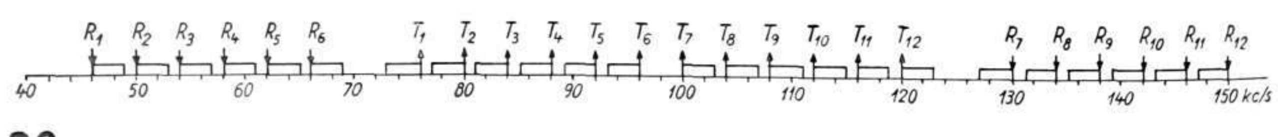
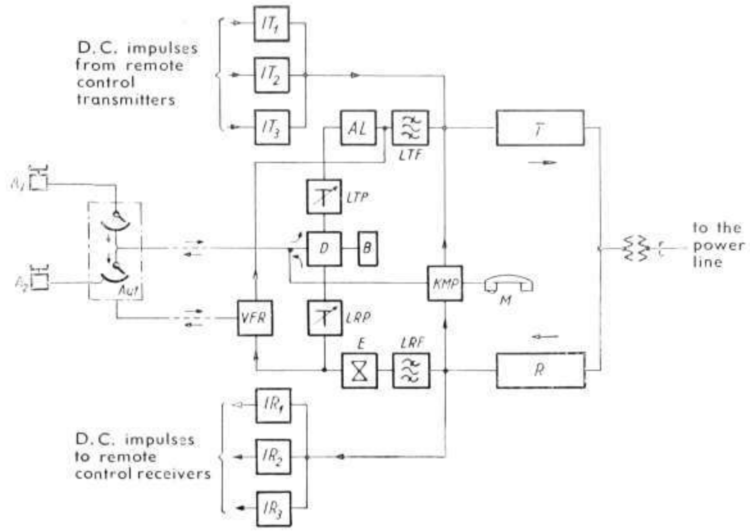


Fig. 27 X 6147

Diagram of a terminal equipment for a telephone channel and superimposed voice frequency impulse channels

A	telephone instrument
AL	amplitude limiter
Aut	automatic telephone exchange
B	balancing network
D	differential transformer
E	equalizing network
IR	voice frequency impulse receiver
IT	voice frequency impulse transmitter
KMP	monitoring panel
LRF	voice frequency filter of the receiver
LTF	voice frequency filter of the transmitter
LRP	loudness control of the receiver
LTP	loudness control of the transmitter
M	handset (= microtelephone)
R	high frequency receiver
T	high frequency transmitter
VFR	voice frequency ringing device



to a higher degree the more carefully the balancing network *B* simulates the impedance of the two-wire line including the equipment of the telephone exchange and the connected telephone instrument. On the transmitter and receiver sides of the differential transformer, potentiometers will be found for the volume control and low frequency filters which limit the speech band to 300—2400 c/s. The transmitter side of the fork equipment includes also an amplitude limiter *AL* which automatically cuts off the tension peaks of too loud speech which might overcharge the channel and thus produce disturbances between transmitted signals.

Owing to perfect low and high frequency filters, the voice frequency tensions are transmitted without any attenuation distortion worth mentioning. To this the favourable design of filters and high frequency choke coils also contributes. A very typical over-all attenuation curve is shown in Fig. 28 for a telephone channel. It shows the attenuation at different voice frequencies between the two-wire terminals of the transmitter station and the corresponding point of the receiver station. The over-all attenuation is zero in this case. It may be altered to other values by means of the volume control potentiometers in the fork equipments. The filters, especially the low frequency filters, have larger attenuation at the cut-off frequencies of the bands than in the middle of the bands. In order to correct this as well as all eventual attenuation peaks of the line the receiver is equipped with an equalizing network *E* which is adjusted when the equipment is put into service. Owing to the fact that in such a way every individual communication is given a perfect over-all attenuation several telephone channels may be connected in cascade without the speech quality being impaired.

The greater the number of carrier frequency sections participating in a communication the greater demand have to be put on the equilibrium of the diffe-

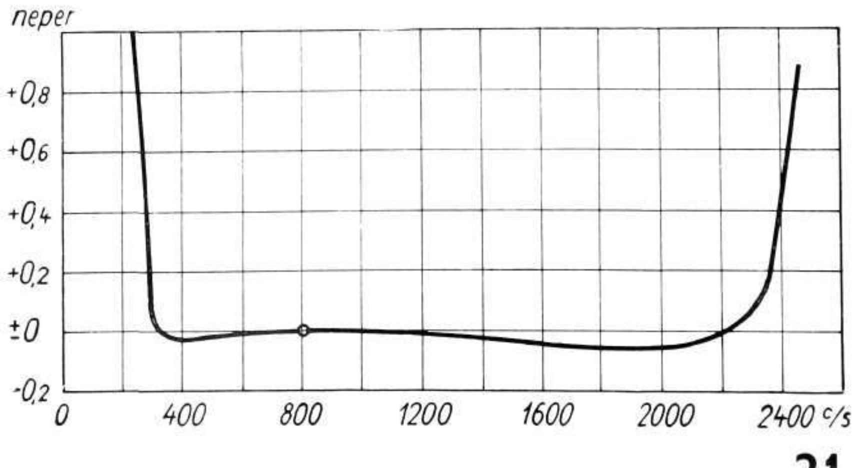


Fig. 28 X 6172

Over-all attenuation of a telephone channel as a function of the frequency rential transformers in order to prevent reaction taking place in the equipment. When the limit is approached the speech quality is appreciably deteriorated and therefore not more than four or at most five telephone channels may be connected in cascade by means of two-wire connections between the bays, or the equipments have to be equipped with reaction suppressors. This complication is avoided by four-wire connections between the bays which means that the receiver and the transmitter of one terminal equipment are connected directly, i. e. without differential transformers, to the transmitter and the receiver respectively of the following terminal equipment in the same station.

Telephone Switchboards and Signalling Device

A number of telephone instruments within a station area may communicate with telephone instruments in other stations via the telephone channels with the aid of the telephone switchboards of the stations. They are designed either as manual or as automatic switchboards. These switchboards have partly to establish connections wanted and partly to prevent that telephone instruments are being connected to an existing communication. The manual switchboard may be served, for instance, by the attendant in the control room of the station. The automatic exchange makes the connections automatically when the number of the subscriber wanted is dialled on the telephone instrument. In most cases the telephone communications of a power line network are arranged for automatic dialling.

The special automatic switchboard of LM Ericsson for carrier frequency telephone communications on power lines may have a total of ten lines connected. They may come from telephone instruments, other telephone exchanges and from carrier frequency equipments. For every line incoming to the switchboard there is a relay equipment which is of different design for local lines and for carrier frequency channels. The relay equipments are connected to the bay cable of the switchboard by means of plugs and jacks. The bay is shown in Fig. 29. It is constructed for wall mounting. At the top of the bay a connecting strip is located for incoming lines and for the connection of D.C. voltage of 24 V for the operation of the switchboard. Under this strip the common ringing equipment is mounted and below it all the ten relay equipments of the lines are mounted in the same order as the dialling numbers 0, 1—9 assigned to the different lines.

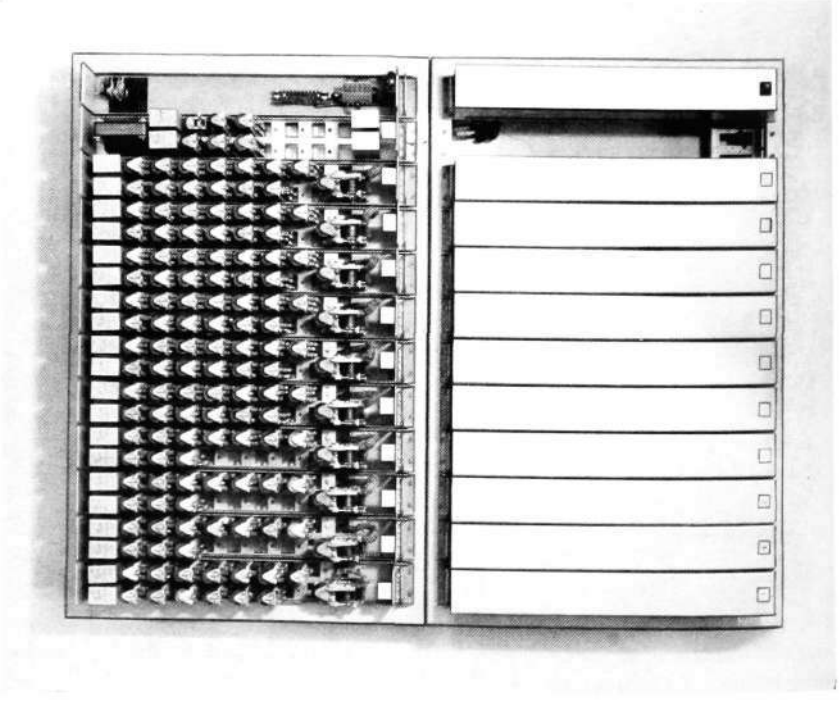


Fig. 29 X 6175

Automatic telephone exchanges

left: without dust covers; right: with dust covers

Every relay equipment has its own selector which means that five simultaneous communications may be established independent of each other in an entirely complete switchboard. Communications may be arranged between telephone instruments of the same station, the exchange thus acting as a local switchboard, between a telephone instrument and a carrier frequency channel and between two carrier frequency channels i. e. for the through-traffic of a long telephone communication.

By intermittent or continous buzzer tone the person dialling is informed during the establishment of the communication if the section just dialled is occupied or not. When the person dialling has reached the wanted extension this one gets automatically ringing current with intermittent signals, the person dialling hearing then a ringing tone. The speaker replacing his handset first is immediately disconnected and may dial anew. The carrier frequency communication is disconnected in its entirety by means of clearing signals which are transmitted when one of the subscribers replaces his handset down. A carrier frequency circuit is freed after a certain time if it has been occupied owing to false signals.

Conversation with this equipment is not secret. A person who has dialled the number of an occupied subscriber can thus listen to the conversation proceeding but the two speakers are warned at the same time by a faint intermittent tone. If necessary the incoming person may ask for the call proceeding to be ended at once. If a carrier frequency channel should be busy the person dialling gets a tone which announces that the channel is occupied. If nevertheless he wants to come into communication with the speakers he dials a certain number. Then the busy ton disappears and a warning tone is transmitted to the speakers and at the same time the person dialling can speak with them. When at his request they have finished their call the person dialling may continue his dialling. Important communications may thus always be established in spite of channels on their way being occupied.

If the number of lines in a station should happen to be larger than the capacity of the switchboard allows, secondary switchboards may be installed. Automatic switchboards of other types with larger capacity may also be used if they are equipped with special relay equipments for the carrier frequency channels. Relay equipments exist also which permit communication via telephone lines between the primary switchboard of a high frequency station and switchboards in other stations. With joint traffic between different power line networks, manually supervised through-connection of the communications between the two network groups is often wanted and therefore special devices have been designed for this sluicing.

In large networks with many switchboards it would be difficult to establish a long communication by means of the dial, number by number. The number for a given subscriber will be different according to where the dialling is done and its length will depend on the number of channels that have to be interconnected. This is avoided if the switchboards are equipped with registers which automatically transmit the necessary complicated impulse series. Every telephone instrument is then given its special station number and a subscriber number and thus universal numbers are obtained which are valid within the whole network and, even in large networks, need not consist of more than four or five figures at the most, according to the size of the station.

The impulses of the switchboards of a carrier frequency communication are transmitted as voice frequency impulses in the telephone channel. The transformation from D.C. impulses to voice frequency impulses and vice versa is made in the voice frequency signalling set *VFR* as per the diagram of Fig. 27. This apparatus is a combined transmitter and receiver for the signal frequency, 1000 c/s, which thus is chosen within the voice frequency range. Normally the *VFR* is prepared to receive signals from the far end station but is automatically switched for transmitting the signals of the switchboard of its own station. The receiver is only influenced by pure voice signal frequency. Thus speech which is always made up of several frequencies is prevented from giving false signals.

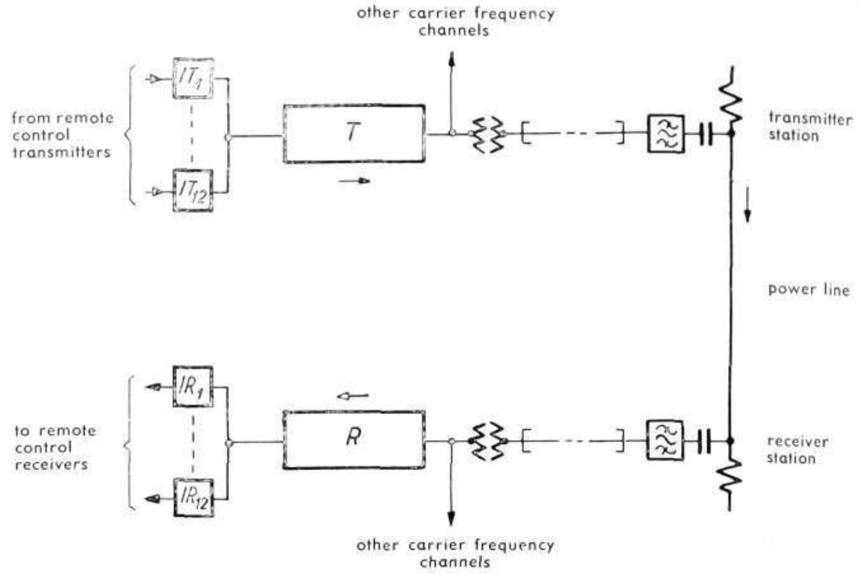

other carrier frequency channels
from remote control transmitters
IT_1
IT_{12}
T
transmitter station
power line
to remote control receivers
IR_1
IR_{12}
R
receiver station
other carrier frequency channels

Fig. 30 X 6171
Diagram of a high frequency remote metering channel with voice frequency impulse channels

- IR voice frequency impulse receivers
- IT voice frequency impulse transmitters
- R high frequency receiver
- T *high frequency transmitter*

In a carrier frequency communication composed of several cascade-coupled channels the voice frequency impulses are normally transmitted directly without being repeated by the relays of the intermediate exchanges. The transmission may therefore be made via a great number of switchboards without impulse distortion.

On a channel direct conversations may be made between the telephone bays without using the telephone switchboards. The telephone bay is therefore equipped with a handset which may be connected by means of the monitoring and control panel *KMP* for monitoring and conversation on the channel. It may also be used for supervision of all other low frequency circuits of the bay. As a ringing signal from the *KMP*, the frequency 2000 c/s is used. The relay of the ringing current receiver has delayed action of such duration that speech tensions of this frequency do not have time to actuate the receiver relay. The *KMP* is used also as ringing apparatus in the cases when the telephone bay is connected to a manual switchboard. On ringing from such a switchboard the ringing current 20 c/s actuates an A.C. relay which switches the *KMP* for the transmitting of 2000 c/s. In the receiver station a receiver relay transforms the voice frequency ringing signal to normal ringing current.

Superimposed Voice Frecuency Impulse Channels

In a telephone channel the low frequency range above the speech band is used for three superimposed remote metering channels with the voice frequencies 2640, 2760 and 2880 c/s in one direction and 2700, 2820 and 2940 c/s in

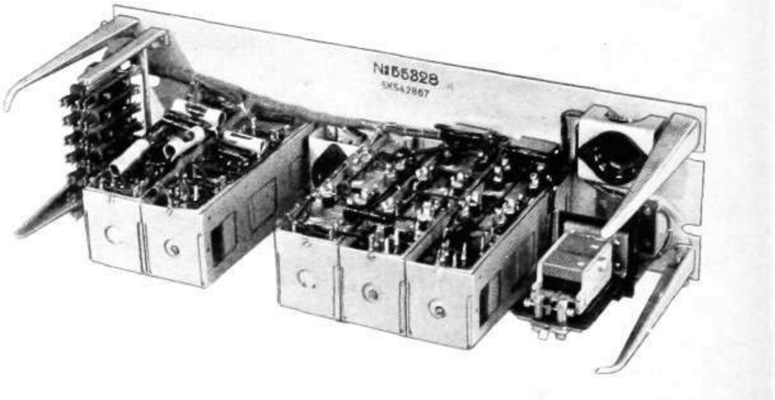


Fig. 31 X 6170
Suplementary high frequency device for the selective line protection

furthest to the right: the polarized receiver relay the other. In the equipment of such a voice frequency impulse channel according to Fig. 6 the transmitter relay is a static one and consists fundamentally of a bridge circuit the equilibrium of which is piloted by the D.C. impulses of the impulse transmitter. At zero current the bridge is fully equilibrated and the voice frequency from the oscillator is thus impeded by this relay. D.C. current through the relay breaks off the equilibrium and the voice frequency is given free passage. The relay has no inductance and requires very small pilot power which is important for the length of life of the contacts in the transmitting rotary electricity counters which often are very sensitive to sparks in the commutator. Moreover the relay is free of inertia and requires no supervision, unlike mechanical relays.

The voice frequency impulses of the three voice frequency impulse transmitters are delivered to the intermediate frequency modulator *MM* and transmitted to the receiver of the remote station according to Fig. 19 and 27. After the amplifier *LA* the speech and the superimposed frequencies are separated from each other. The latter are supplied to the three voice frequency impulse receivers *IR* which are designed with individual automatic level regulation with a range of voice frequency level variation of about 2 nepers.

The speech is prevented from disturbing the voice frequency impulses by the fact that the speech band is limited to 2400 c/s by the low frequency filter *LTF* in the transmitter. Speech tensions which have frequencies within the superimposed bands are thus cut off before they are delivered to the carrier frequency transmitter. As already the speech power is cut down by the amplitude limiter before the modulation. Thus a given maximum degree of modulation can never be exceeded by the speech. Thus internal disturbances between telephony and remote control by overload of transmitter and receiver are prevented.

In the receiver the superimposed frequencies are prevented from entering the telephone instrument by the filter *LRF* of the telephone receiver which is

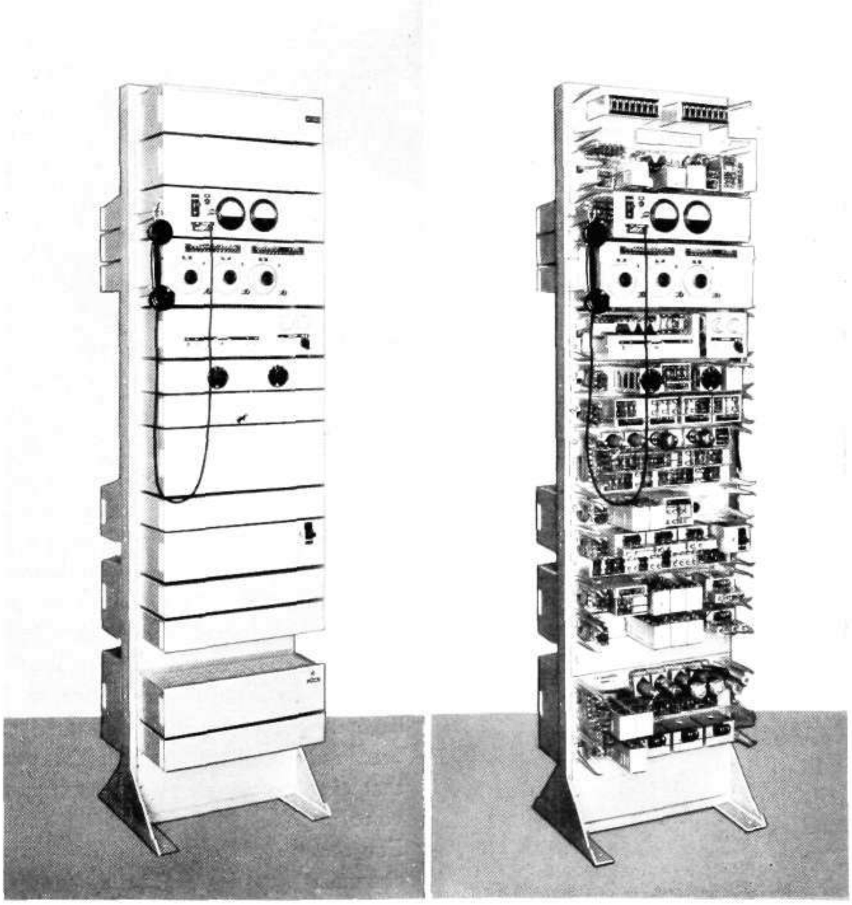


Fig. 32 X 6155

High frequency telephone bay

left: with dust covers; right: without dust covers

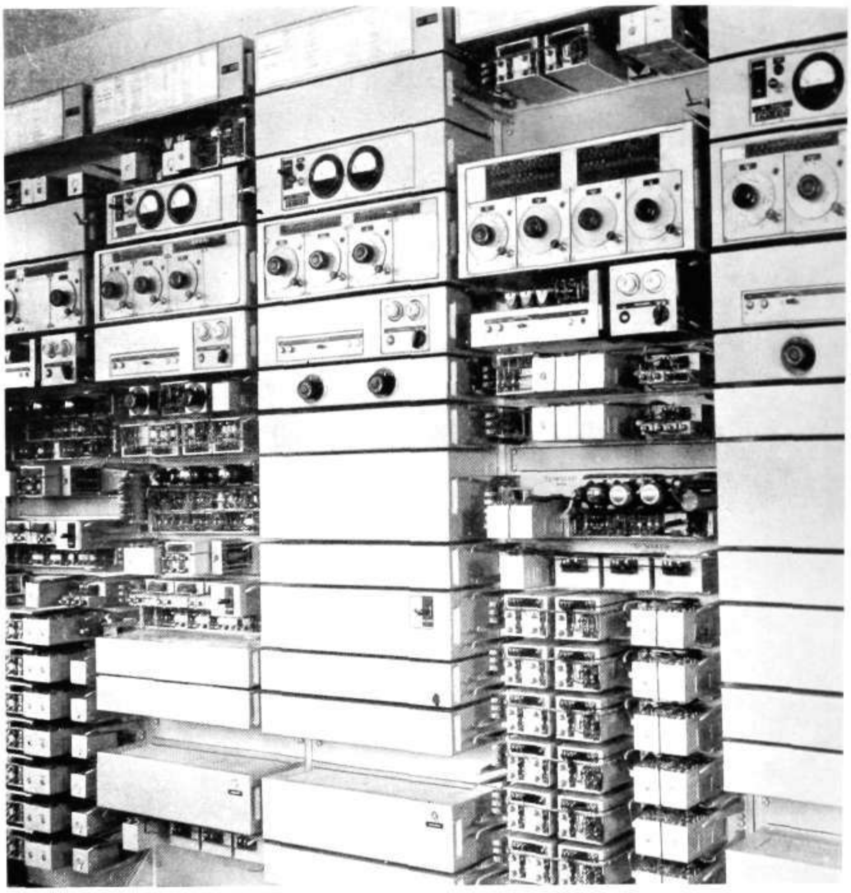


Fig. 33 X 6156

Part of the row of bays of a large high frequency station

Furthest to the left of the picture a part of a remote control receiver bay will be seen with seven of the eight voice frequency impulse receivers at the bottom of the bay. The second bay from the right is a remote control transmitter bay with in total twelve voice frequency impulse transmitters. The other bays are all telephone bays.

passed only by the frequencies below 2400 c/s. The telephone channel and the remote metering channels have a common carrier frequency equipment which is designed in such a way that the intermodulation between the superimposed frequencies and the speech frequencies is insignificant. Modulation products between the three voice frequencies may naturally arise but they all fall outside the speech band; the frequency differences 120 and 240 c/s lie below this band and the frequency sums lie above it.

The modulation degrees of the high frequency transmitter are 100 percent for telephone speech and 30 percent for each of the superimposed voice frequencies.

High Frequency Remote Metering Channel

If more remote metering or control channels are needed in a circuit than the three which may be superimposed in each direction of a telephone channel or if remote metering communication has to be arranged between stations which are not equipped with telephone communication on the power line, a separate carrier frequency channel is necessary for the transmission. Such a channel is normally arranged in one direction only and thus the equipment is divided into one transmitter bay and one receiver bay. The high frequency transmitter of such a communication is modulated with a number of voice frequencies within the speech band, see Fig. 30, each representing a remote metering or control communication. Through single sideband transmission and high degree of modulation in the transmitter the effect of disturbances has been reduced for the individual voice frequency channels to such an extent that even for long communications on lines with high noise level up to eight voice impulse channels may be transmitted by one carrier frequency channel. For short distances or on lines with lower noise level twelve or even more channels may be transmitted.

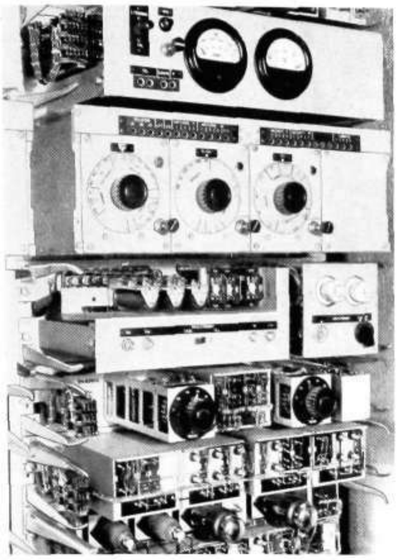


Fig. 34 X 4392

Supervisory equipment of a telephone bay

At the top: the monitoring and control panel; below: the switching panel and the current distribution panel. Below these the fork equipment with differential transformer and low frequency filter. At the bottom: the receiver amplifier of the high frequency part.

The voice frequencies are odd multiples of 60 c/s with a mutual distance of 120 c/s and with the lowest value equal to 660 c/s. Thus the following channel frequencies are 780, 900, 1020 c/s etc. By choosing the frequencies in this manner all dangerous harmonics and combination frequencies which may eventually be produced by means of intermodulation fall within the intervals between the voice impulse channels, which thus are protected against disturbances of that kind.

If the need of remote metering channels is so small that only one channel is wanted (and no telephone channel) an impulse channel is arranged within the high frequency range. The high frequency of an oscillator is chopped directly to impulses by the remote metering transmitter without any previous modulation in the same way as in a voice frequency impulse transmitter according to Fig. 6. The receiver consists of a band pass filter and a high frequency impulse receiver.

Voice Frequency Impulse Channels for Teletyping

Important reports or orders are by preference given in writing and teletyping may therefore be a useful supplement to the telephony. As stated, the teletyping machine transmits impulses with a maximum frequency of 25 c/s. By transmitting these impulses through a voice frequency channel within the speech band the telephone channel may be used also for teletyping. To switch over to teletyping, a special switch is pulled or a number is dialled on the telephone instrument and after this the teletyping communication is established. Fixed teletyping communications may also be arranged very simply by means of a superimposed voice frequency channel in each direction. Nevertheless, the band width of this channel must be larger than in a remote metering channel and thus there is only space for a single teletyping channel above the speech band. The voice frequencies used are 2760 and 2820 for the different directions.

In pure high frequency metering channels, teletyping communications may be installed without reducing the number of voice impulse channels.

High Frequency Selective Protection

By collaboration between ASEA and LM Ericsson a selective protective device has been developed in which the two carrier frequencies of a two-directional carrier frequency channel is used for the release signals to the breakers of the power line. The telephone bay is in this case equipped with an additional device *S* in Fig. 19 and 31, which contains a transmitter relay and a receiver relay. The transmitter relay cuts off the outgoing carrier frequency current by order of the relay equipment *R* of the protective device which is a somewhat modified normal distance relay protective device. The receiver relay is influenced by this cut-off of the carrier current in the far station and forwards this impulse to the relay equipment. By special means the receiver relay is made insensible to disturbances from electrical arcs on the line.

By this combination protective device a momentary disconnection of the faulty line section is obtained whereever the fault may be along the whole distance. In case of fault in the high frequency transmission the high frequency protective device is disconnected immediately and the distance protective devices are automatically switched on to supervise alone the stretch in question. Thus the distance protective device participates in the selective protective device and gives also simultaneously a complete emergency reserve for this device.[1]

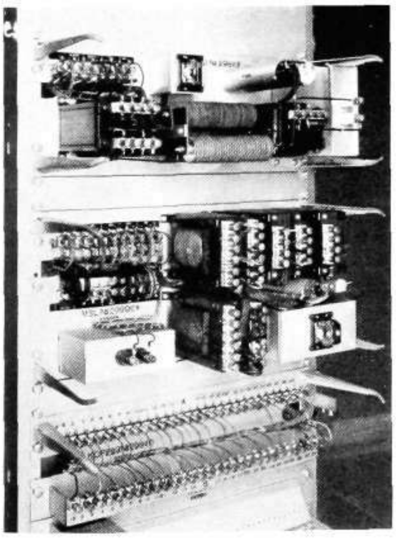


Fig. 35 X 4393

Mains supply panels at the rear side of the bay

At the top: the MSH and below the MSL; at the bottom: the connecting panel

The Construction of the Bays

The devices of an equipment are divided into panels which are mounted on both sides of an U-iron frame according to Fig. 32. The height of the frame is 2020 mm, the breadth is 514 mm and the depth 426 mm when the panels

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[1] See *Holm, T:* High frequency selective protection as a complementary protective device. Teknisk Tidskrift 1945 h. 27 pp. 768—771.

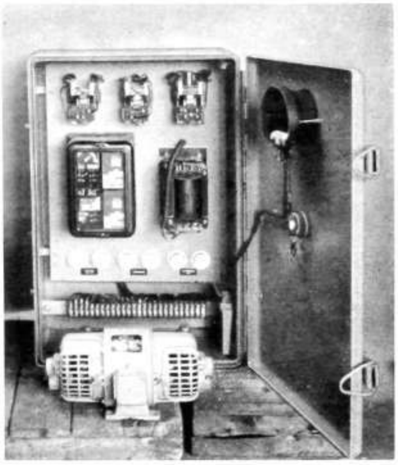


Fig. 36 X 4394
Emergency current device

consisting of a single anchor converter with its relay equipment

are mounted. Every panel is protected against dust by a cover easy to remove. Between the front and the rear panels are placed the cables which connect the different panels with each other. By this way of mounting used in all the transmission equipment of LM Ericsson, all parts are very easy of access for control and inspection.

The front of the telephone bay has at the top a panel which has place for spare parts under the dust cover. A drawing fixed on the cover shows the location of the different panels of the bay and gives particulars of frequencies and other important data. The next panel below, the voice frequency ringer, produces as well as receives the voice frequency impulses which are used for the automatic selection between the telephone switchboards of the stations. After these panels follows the supervisory panel with the measuring instruments for the measurement of currents and tensions and with the equipment for monitoring and for ringing to and conversation with the remote station.

By means of the control knobs of the next panel, the switching panel, the different circuits of the bay are connected to the above mentioned measuring instruments for measuring currents and tensions. The panel contains also jacks in which the most important circuits of the bay are accessible by means of plug cords. The next panel, the current distribution panel, contains current switches, pilot lamps and fuses for the different tensions of the bay. By means of the knobs of the following panel the output and input levels are regulated. Moreover the panel contains a differential transformer which connects the telephone exchange with the transmitter and the receiver via a two-wire circuit. The low frequency filters are mounted on the next panel below. They separate the speech band from the frequencies of the superimposed voice frequency channels. After these panels come the panels of the high frequency receiver. They are the amplifier panel, the high frequency demodulator and the band filter. The high frequency transmitter consists of the four panels at the bottom of the front. They are the intermediate modulator, the high frequency modulator, the transmitter amplifier and the transmitter band filter. The pilot lamp on the transmitter amplifier is lit while the transmitter is modulated.

Incoming wires to the bay are generally ducted in a pipe in the floor. They are ducted to the entrance panel at the bottom of the back of the bay where they are fastened. They are then connected to the pole-screws of the above panel, the connecting panel. Above these panels the mains supply units of the bay are to be found. By these panels the A.C. voltage of the mains is transformed to the different tensions which are necessary for the operation of the equipment.

The rest of the back of the bay is reserved for the selective protective device and the equipment for the superimposed voice frequency impulse channels. The bay in Fig. 32 is for a circuit with superimposed channels in one direction only and this contains three voice frequency impulse receivers. Above these panels there is place for three transmitters for the opposite direction. The bay is always delivered with cable connections for a complete number of voice frequency impulse channels and may therefore be completed very simply by the equipments of more such channels according to requirements.

The high frequency metering transmitter and receiver bays are constructed in a manner similar to the telephone bay of Fig. 33. Of these two bays, there are two types which have cable connections for eight and twelve voice frequency impulse channels respectively.

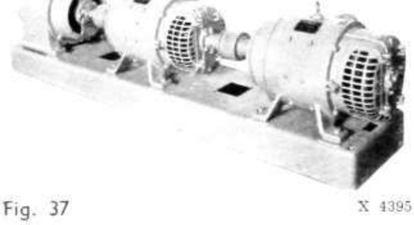


Fig. 37 X 4395
Emergency current converter

A.C. generator with D.C. and A.C. motors mounted on the same axle

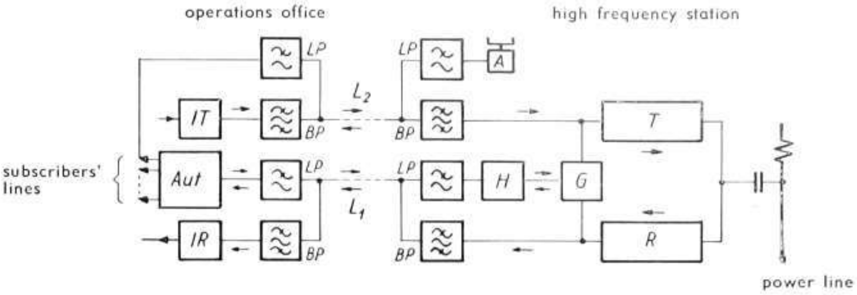
Supervisory Arrangements

All important currents and tensions may be measured by the instruments of the bay. On the supervisory panel at the top of Fig. 34 a D.C. instrument and an A.C. voltmeter are to be found. The D.C. instrument measures current

Fig. 38 X 6148

Diagram of the telephone equipments of the operations office and the high frequency station connected with each other via two-wire lines

A	telephone instrument
Aut	telephone exchange
BP	band filter for superimposed voice frequencies
G	fork equipment
H	relay equipment
IR	superimposed voice frequency impulse receivers
IT	superimposed voice frequency impulse transmitter
L_1 L_2	two-wire telephone lines
LP	low pass filter
R	high frequency receiver
T	high frequency transmitter



and tension. The switching panel consists of three switch units and has place for one more unit if required. The tension or current to be measured is selected by the rotary switches, according to the engraved dials of the switches. The reading is done on one of the two instruments by pressing the push button switch which will be found on the unit in question. From left to right the first unit enables the measurement of anode voltages and the microphone voltage as well as the anode currents of the high frequency valves and the pilot current of the level regulator; the second unit gives the anode and relay currents in the voice frequency impulse equipment; and the third unit gives the A.C. voltages as the mains voltage, the filament voltages as well as the voice frequency and high frequency tensions.

The fuses of the mains supply units have separate alarm contacts which open when the fuses are blown. All the other tensions have fuses and zero voltage relays. The contacts of these fuses and relays are connected in series thus forming a constant current chain which is connected to a common external zero current relay. This relay actuates the alarm bell of the station in case of any faults. The lamps of the current distribution panel are normally lit. In case of alarm the nature of the fault can immediately be ascertained by the fact that the corresponding lamp has gone out.

The jacks in the voice frequency circuits are both parallel jacks without break off the circuits and series jacks in one direction with break of circuit in the other. External measuring instruments or phones are connected if needed into the jacks by means of plug cords which are supplied with the bay.

Power Supply

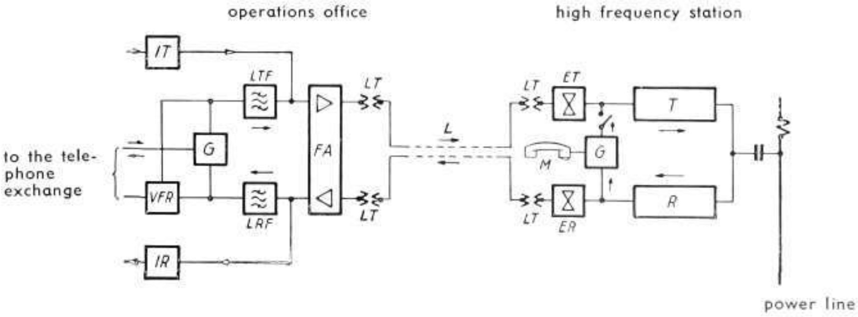
The necessary power for the operation of the equipment is delivered from the A.C. mains or from an emergency current converter.

The carrier frequency bay has two mains supply units with the type designations *MSL* and *MSH*, see Fig. 35. The set *MSL* delivers anode voltage of 160 V to the low power valves, A.C. voltage to the parallel connected filaments of the valves as well as the alarm and mark voltage. In order to match the unit to different mains voltages an auto-transformer is mounted on the panel. The other mains supply set *MSH* delivers anode voltage of 360 V to the output valves of the transmitter. Metal rectifiers are used throughout for the rectification of the alternating current. Bays with voice frequency impulse transmitters are equipped with a third mains supply unit which gives the operating voltage for the transmitter relays. If the voltage of the mains varies

Fig. 39 X 6149

Diagram of the telephone equipments of the operations office and the high frequency station connected with each other via a four-wire line

ER	equalizer of the receiver
ET	equalizer of the transmitter
FA	four-wire repeater
G	fork equipment
IR	superimposed voice frequency impulse receivers
IT	superimposed voice frequency impulse transmitters
L	four-wire telephone line
LT	line transformer
LRF	telephone filter of the receiver
LTF	telephone filter of the transmitter
M	handset
R	high frequency receiver
T	high frequency transmitter
VFR	voice frequency ringing device



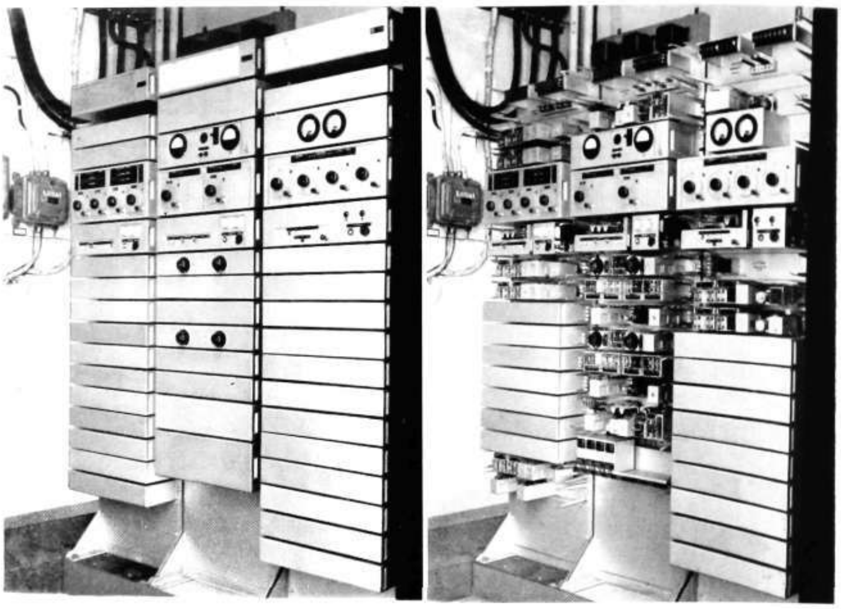


Fig. 40 X 6157

Row of bay of the operations office

for the connection with high frequency stations via cable circuits

more than ± 10 % of the normal value the equipment must be equipped with a voltage stabilizing set. The mains power of a telephone bay including superimposed metering channels is about 200 w at $\cos\varphi = 0.95$. The power consumption of a high frequency metering transmitter bay with eight impulse channels is 175 W and of the corresponding receiver bay 70 W.

The telephone switchboard is supplied with D.C. voltage of 24 V from a battery with charging rectifier or from a separate mains supply unit which has to be stabilized within ± 2 V even if the current consumption of the exchange varies from 0 to 3 A. This voltage supply is also used to supply the microphone of the telephone bay.

In order to be independent of interruptions in case of faults, current failure and voltage reduction of the local A.C. mains the station is generally equipped with an emergency converter which is run by D.C. from the accumulator battery of the power station and which delivers A.C. voltage to the carrier frequency equipment, telephone switchboard and remote metering and control equipment of the station. For smaller stations where a short interruption of the communications is of little importance a single armature converter is used which is started automatically by a relay device when the mains voltage fails, see Fig. 36. No interruptions however brief can be allowed in circuits with high frequency selective protection. The A.C. voltage for stations with such equipment therefore is delivered continuously by the A.C. generator of a steadily rotating unit. A three-machine aggregate of a large station is shown in Fig. 37. The mains supplied A.C. motor normally drives the whole unit. If the mains voltage fails or is reduced below a permitted minimum value the D.C. motor is automatically connected to the battery of the station in order to drive the generator. During the switching moment the momentum of the unit is sufficient to maintain revolutions and thus also the A.C. voltage of the generator. The emergency converters are manufactured by ASEA for L M Ericsson's account.

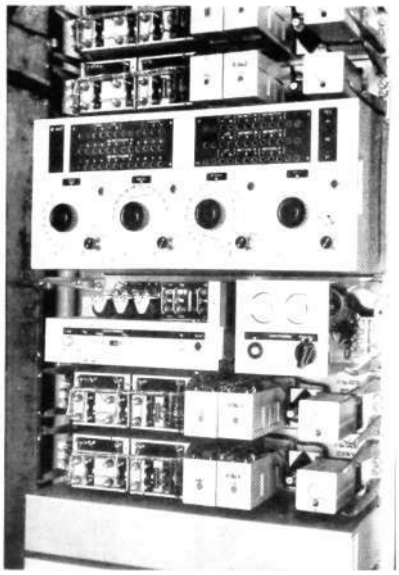


Fig. 41 X 4392

Part of a bay with voice frequency impulse equipment

At the top and at the bottom: voice frequency impulse receivers. At the middle of the bay: supervisory equipment

Valves

The types of valves which are used in the equipments have at least 5000—6000 hours' life. Nevertheless the life has proved appreciably longer for many valves in existing plants.

The Connection of Local Stations to a High Frequency Terminal

The power lines which serve a large town will often end at a switching frame which is situated in one of the suburbs of the town while the operations office of the power line network is situated in the centre of the town. To this office all the communications converge. The distances between a power station and its substations are often so short that the communication of signals between the stations will not be economical when using carrier frequency systems on the power lines. Telephone communication and remote metering and control must in such cases be arranged by using telephone or signalling lines between the high frequency station and the other stations. The equipments are generally designed for several simultaneous communications allocated to different frequency bands on the same line circuit. Some typical communications are described below.

A telephone communication may be extended from the high frequency station to another station by equipping the telephone switchboards of the two stations with special relay equipments for the transfer traffic on a two wire line. The super-imposed voice frequencies in one of the two directions may be transmitted on the same circuit as the telephone communication if band filters for the voice frequency impulses and low pass filters for the telephone speech are connected to the circuit in the two stations. The high frequency station in the diagram of Fig. 38 is supposed to need one telephone instrument only and it has therefore no telephone switchboard of its own but only a relay equipment *H* serving the connection of the telephone channel to the switchboard of the operations office via the two-wire line L_1. This circuit transmits also the superimposed voice frequency impulses received to the impulse receivers *IR* of the operations office. The telephone instrument of the high frequency station is connected to the exchange of the operations office via another circuit L_2 which is simultaneously used for the transmission of the voice frequency impulses from the impulse transmitters *IT* of the operations office to the carrier frequency equipment. Both lines are equipped with filters *LP* and *BP* for the separation of the speech frequencies and the voice frequency impulses from each other.

For long communications four-wire lines must be used, especially when cable circuits are used between the stations, in order to ensure that sufficient loudness of sound will be obtained in the telephone instruments connected to the

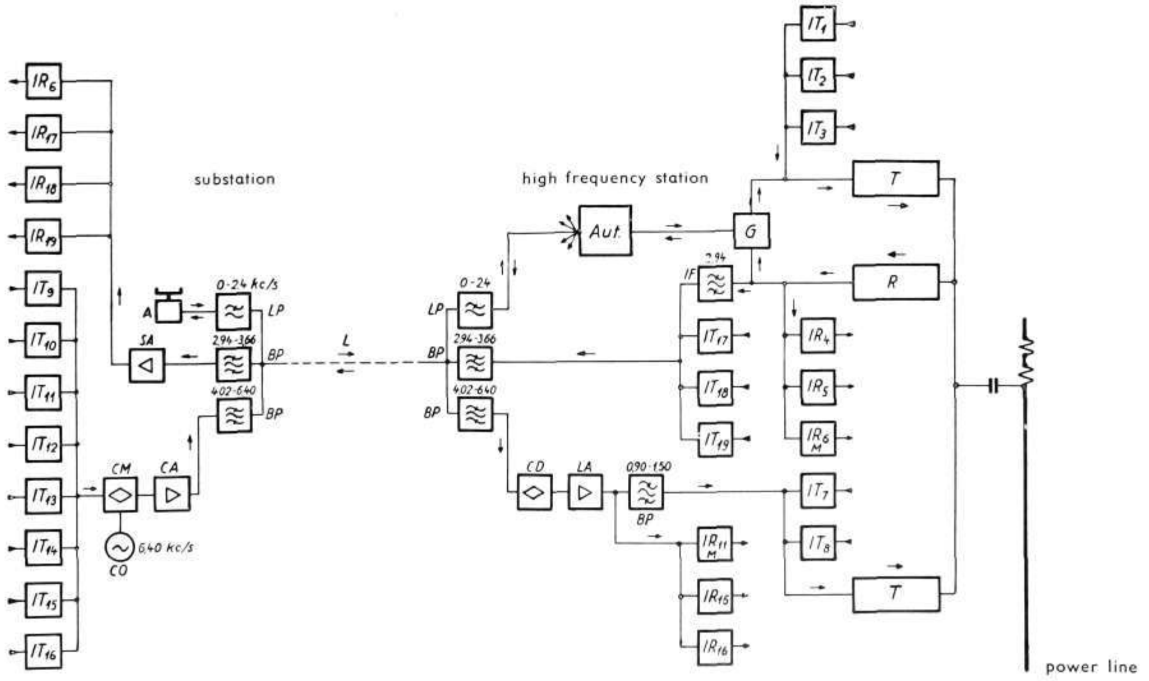
Fig. 42 X 7403

Diagram of the telephone and remote control equipments of a high frequency station and its substation

A	telephone instrument
Aut	telephone exchange
BP	band filter
CA	carrier frequency amplifier
CD	demodulator
CM	modulator
CO	carrier frquency oscillator
G	fork equipment
IF	voice frequency impulse filter
IR_{1-19}	voice frequency impulse receivers
IT_{1-19}	voice frequency impulse transmitters
L	two-wire overhead line
LA	voice frequency amplifier
LP	low pass filter
M	supervisory receiver
R	high frequency receiver
SA	amplifier for superimposed voice frequencies
T	high frequency transmitter

The index figures design the numbers and frequencies of the voice frequency channels according to the table below:

1	2.64 kc/s	11	1.14 kc/s
2	2.76 »	12	1.26 »
3	2.88 »	13	1.38 »
4	2.70 »	14	1.50 »
5	2.82 »	15	1.74 »
6	2.94 »	16	1.86 »
7	0.66 »	17	3.18 »
8	0.78 »	18	3.42 »
9	0.90 »	19	3.66 »
10	1.02 »		

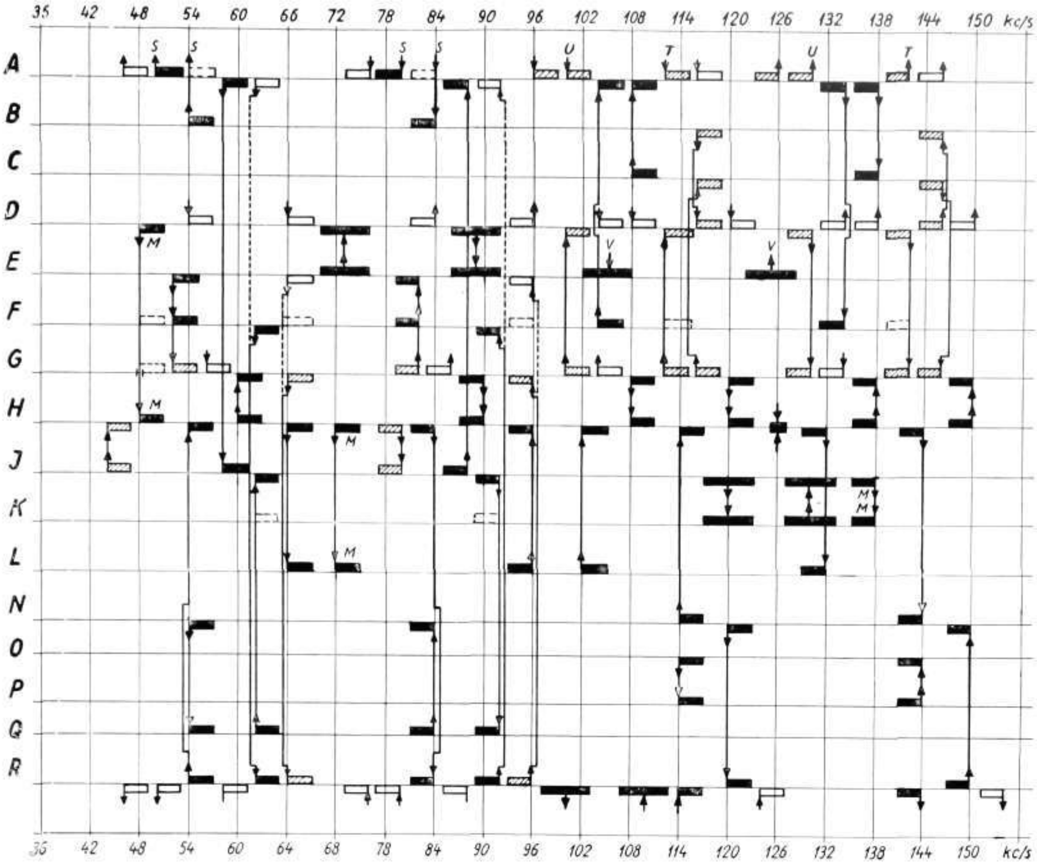


exchange. When using a long two-wire line difficulties arise in getting such an exact equilibrium in the fork equipment that reaction is not obtained causing howling if the amplification of the receiver is augmented sufficiently to compensate the attenuation of the two-wire line. Moreover if the characteristic impedance of the line has an uneven course with frequency the equilibrium will be more difficult to realize. When using four-wire transmission according to Fig. 39 the normal fork equipment is simply broken out from the telephone bay and mounted in a fork bay which is placed in the other station. The fork bay contains a four-wire repeater *FA* to compensate the line attenuation. The equalizing networks *ET* and *ER* equalize the dependence on the frequency of the line attenuation. The attenuation of a cable circuit increases sharply with the frequency. The voice frequency impulse equipment is mounted in the fork bay and thus no more signalling circuits are necessary between the two stations for the superimposed remote metering and control communications. In the high frequency station the telephone bay is equipped with a simple fork equipment containing filters and differential transformer by which the handset of the bay may be connected to communication.

In the corresponding way according to Fig. 30 the voice frequency impulse equipments of a high frequency channel may be mounted in separate bays to be installed in the operations office. All the voice frequency impulses of the same direction are in this way transmitted on a common two-wire line from the high frequency receiver or to the high frequency transmitter in the power station.

The bays shown in Fig. 40 contain the terminal equipment in an operations office for the cable junctions with two high frequency stations. Twelve voice frequency impulse channels arrive to the office from the high frequency metering receiver bay in the first one of the stations. The bay furthest to the left contains the voice frequency impulse receivers of these channels and moreover all the voice frequency impulse equipment of the superimposed impulse channels of two telephone communications. The fork equipments of the telephone channels are mounted on the middle bay of the row. For all these communications five circuits, *i. e.* pairs of wires, are necessary, one for the voice frequency impulse channels of the high frequency metering channel and four for the two four-wire telephone communications. Between the office and the second high frequency station the line is sufficiently short to permit two-wire telephone transmission. Thus the fork equipment of this communication is placed in the high frequency station. The voice frequency impulse equipment which communicates with this station is mounted on the bay furthest to the right.

In the more complicated plant of Fig. 42 a two-wire circuit of an open-wire line is used for the transmission of telephone speech and a total of twelve voice frequencies between a high frequency station and its substation. The telephone communication between the switchboard of the high frequency station and the telephone instrument of the substation requires as usual the low frequency band 0—2.4 kc/s. To the substation, four superimposed voice frequencies are transmitted, *i. e.* number 6, 17, 18 and 19 within the band 2.94—3.66 kc/s, of which number 6 is one of the received superimposed frequencies taken out from the high frequency telephone bay by the filter *IF* and number 17—19 are transmitted from the high frequency station to the substation. The channel number 6 is also read in the high frequency station by means of an impulse receiver *IR6M*. From the substation eight voice frequencies are transmitted, *i. e.* number 9—16, by aid of a carrier frequency channel with the carrier frequency 6.40 kc/s and with the lower side band transmitted. Of these impulse channels number 15—16 are used for remote metering and control connections between the two stations while number 9—14 are transmitted together with the additional channels number 7—8 by means of a high frequency metering channel on the power line. The channel number 11 is read in the high frequency station by means of the impulse receiver *IR11M*. Moreover in the high frequency station the voice frequencies number



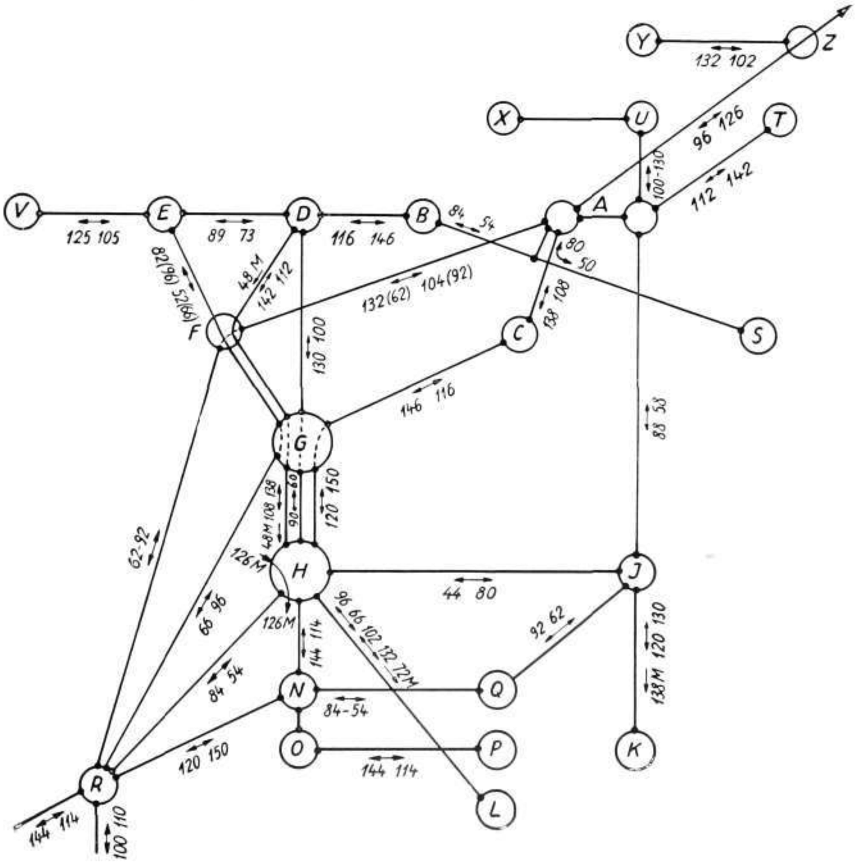


Fig 43 and 44

X 7404
X 6150

Frequency allocation of the carrier frequency communications of the central part of the Swedish network of main power lines

■ existing communications
▨ planned communications
▭ reserved frequency bands
A—L, N—Z station designations
M high frequency remote control channels
All other channels are used for simultaneous telephone communication and superimposed voice frequencies. The numbers assign the carrier frequencies in kc/s

1—3 are transmitted and number 4—5 are received. They are all superimposed on the telephone channel on the power line.

In certain cases it is more suitable that the telephone conversation is transmitted by a carrier frequency channel on the telephone line. Thus by using different frequency bands for the two speech directions, of which one may be the normal low frequency band, only one pair of wires is necessary for a four-wire circuit between the high frequency station and the substation.

High Frequency Network Design

It is necessary that a high frequency network is planned from the beginning in such a way that not only the actual need of telephone and remote metering and control communications will be provided for but also the expansion of the network will be possible when requirements grow in the future. A frequency plan should therefore be made for all existing and planned high frequency bands of the different stations of the network. The frequency plan of Fig. 43 is made for the stations of Central Sweden. Corresponding plans are made also for other parts of the country. The positions of the stations in relation to each other and the high frequency communications between them are shown in Fig. 44.

In order to facilitate the selection of the proper equipments while planning, a great deal of informations is necessary about lines, stations, and the operation conditions of the high tension network. Below are given some of the more important ones:

Actual need of telephone and remote metering and control communications with graduation of the importance of the stations in the high frequency network, main courses and directions of transmission. Carrier frequencies and frequency bands of existing high frequency communications and information about probable future communication needs in order to make possible a rational frequency allocation.

A map of the network with particulars of distances between the stations, line derivations, transformers and sectioning points on the lines. The distances from neighbouring high tension lines which transfer or will in the future have to transfer high frequency. Transformers, breakers and switches of the switchgear between the outgoing lines in the stations. Existing condensers and their capacity values for the estimation of their serviceableness as coupling condensers. The distances between the mounting places of the carrier frequency bays and the line connecting devices in the switching frames.

Working voltages, normal working currents, maximum admissible short circuit currents for the judgement of the necessary types of coupling condensers and choke coils.

The construction of the lines with information about height of the wires, distance between the phases, dimensions and material of the wires for the calculation of line attenuations and the estimation of noise levels.

Information about the voltage of the local A.C. mains and the variations in its tension for the design of the power supply of the equipments. Existing batteries and their voltage and capacity for the design of emergency current converters.

Connected telephone and signalling lines with their dates of construction and their lengths. Informations about existing telephone switchboards which have to be inserted into the network.

The climate and the variations in weather conditions along the power lines and other open wire lines.

Direct Current Potentiometers

S HOLMQVIST, L M ERICSSONS MÄTINSTRUMENT AKTIEBOLAG, ULVSUNDA

U.D.C. 621.317.733

The D. C. potentiometer here described has been developed by L M Ericssons Mätinstrument AB (Ermi). It is partly based on new principles whereby it can be given a double construction, thus taking the place of two separate potentiometers such as are necessary for, e. g., wattmeter control. As the transition resistance in the switches does not affect the measurement figure, great accuracy can be ensured and by means of a special device the resistance figures can conveniently be adjusted to correct values.

General Remarks on Potentiometers

For accurate measurements of D.C. tensions the potentiometer has its obvious employment. The principle of measurement with potentiometer is based on comparison between the tension sought and one that is accurately known. The two tensions are connected against each other and the known tension is regulated to a figure when the difference is nil, this being checked by means of a zero galvanometer, as indicated in Fig. 1. The accuracy of measurement, therefore, is directly governed by the accuracy with which the comparative tension is known, provided the zero galvanometer is sufficiently sensitive.

The requisite comparative tension is obtained in principle from a potentiometer-coupled resistance fed by an electric current. To ensure correct tension over the potentiometer resistance, the current must have the correct value and the resistance must be known, both with sufficient accuracy.

It must be possible to adjust the comparative tension to the desired value, often to within 0.01 % and in certain cases even more accurately. The potentiometer resistance must therefore be furnished with several adjustable tension tappings that can be regulated independently of each other. A single circuit can only be provided with two tappings, as per Fig. 1. In this case the two movable contacts are without current for correct adjustment, so that the contact resistances have no influence on the meter readings.

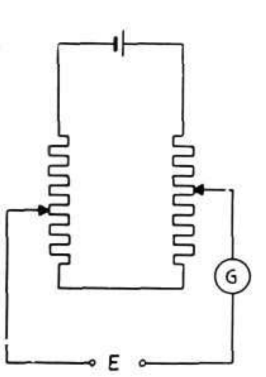


Fig. 1 X 4372
Skeleton diagram of a potentiometer with two decade contacts

If three or four adjusting contacts are required, special couplings must be employed. An arrangement frequently employed is shown in diagram by Fig. 2. With this coupling arrangement the potentiometer tension E may be adjusted by means of the four movable contacts K_1, K_2, K_3 and K_4. If each contact has ten positions and the resistance values are so selected that one step on switch K_4 is equivalent to ten steps on K_3 and one step on K_3 is equal to ten steps on K_2 and so on, the reading will be simple. By selecting resistances and current in suitable manner it will be possible to read off the tension E in, *e. g.*, μV.

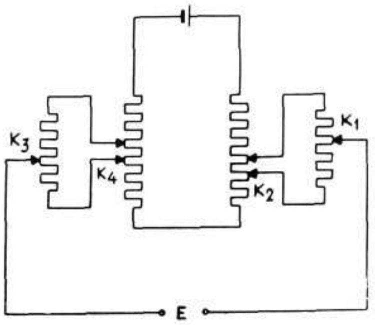


Fig. 2 X 4373
Example of a potentiometer with four decade contacts

The trouble with this and similar couplings used in potentiometers is the unavoidable transition resistances in the switches K_2 and K_4 as per Fig. 2. These must therefore be made with great precision and moreover require regular inspection and cleansing. The effect of transition resistances on the meter accuracy is decreased if the potentiometer is made with high ohm. A usual figure is 10000 ohm/V, thus an auxiliary current of 0.1 mA. This involves the disadvantage that the zero galvanometer must also be high ohmic to ensure good adjustment. This makes the galvanometer sensitive to current which often means trouble as regards insulation. For instance, when checking voltmeters for high tensions, error in meter readings may often be caused by sneak currents.

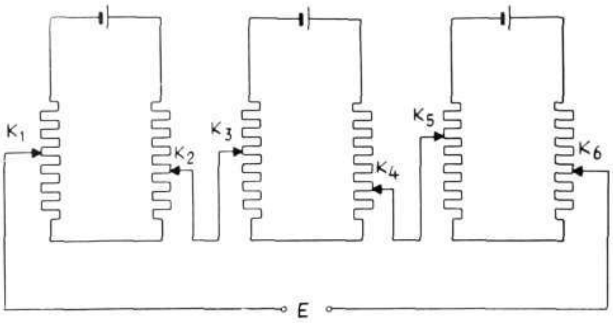


Fig. 3 X 6134
Diagram of connections for potentiometer where the transition resistance in the switches does not affect the metering result

The Principle of Ermi's Potentiometer

To overcome these troubles the D.C. potentiometer constructed by Ermi has been made on another principle. The connection of this is shown in diagram by Fig. 3. The adjustable tension E is obtained from three separate circuits, each fed by its own battery. The auxiliary current amounts to 1 mA in all three circuits. The potentiometer is therefore low ohmic, so that a zero galvanometer with a resistance of 10—100 ohms and a current sensitivity of about 10^{-8} A is suitable. The six switches are all without current, so that the transition resistance does not affect the accuracy of the readings. An objection that can be made against this connection is that each of the three circuits requires separate adjustment of the auxiliary current. In practice this disadvantage has proved to be very small, as each circuit is furnished with a press-button, by means of which the auxiliary current can be checked at any moment. In Fig. 4 this is indicated in the last circuit. Adjustment of the current rarely requires to be done, as the dry cells are but lightly loaded. The risk of the occurrence of sneak currents between the three circuits is also small, owing to the apparatus being low ohmic.

In many a case the measurement of two tensions or currents is required. For example, in resistance measuring and wattmeter control the knobs must be turned when going over from current to tension measurement. This causes great trouble, as the measurement current often varies during the time the knobs are being turned. A great advantage of the new potentiometer is that it may be furnished with two — even with several — compensation tensions independent of each other. By means of a tumbler switch one or the other of the measurement circuits is switched in without needing to turn the knobs.

Fig. 4 shows skeleton connecting diagram for this double potentiometer. The tensions E_1 and E_2 are adjusted separately from each other and are connected in alternately to the outside object of measurement by means of a tumbler switch. The auxiliary current is regulated by rheostats, marked in Fig. 4 by R_1, R_2 and R_3 for the respective circuits. The control of the current is done

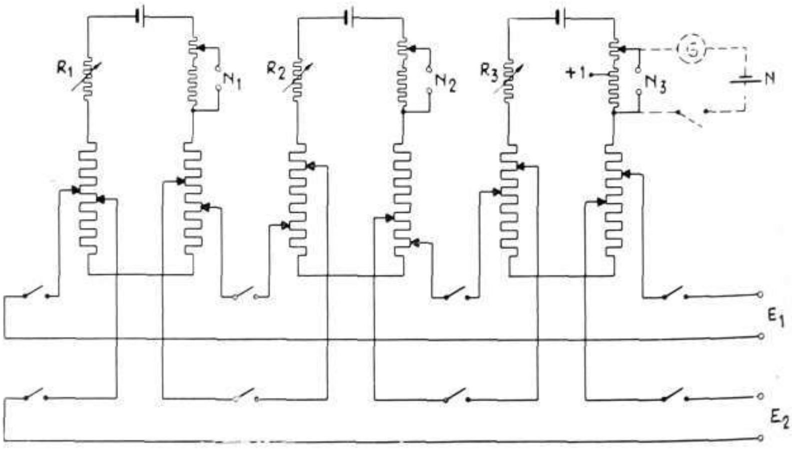


Fig. 4 X 6133
Simplified connecting diagram for Ermi's double potentiometer

in the usual way with a standard cell, which as an alternative may be coupled in series with the zero galvanometer at N_1, N_2 and N_3 by means of a press-button. The same galvanometer is, of course, employed in the adjustment of E_1 and E_2 and is connected in automatically by the tumbler switch. As may be seen from the diagram the N resistance has been provided with switches which can be set at values corresponding to the tension of the standard cell.

The measurement range of the potentiometer can be increased by 1 V to 2.11111 V by means of two other switches, one for E_1 and one for E_2. This supplementary tension is obtained over a tapping on resistance N_3. In this case the last switch is not connected, which involves error not exceeding 0.001 %. In Fig. 4, this tapping is designated by + 1.

The greatest trouble in the making of potentiometers lies in the adjustment of all the precision resistances. To obtain the desired accuracy the resistance values must be correct to within some thousandth part of one percent. In this new potentiometer, a method, for which patent is applied, has been used where the fine adjustment can be made very accurate and without difficulty to within 0.001 %. The absolute values of the resistances in a potentiometer have no significance, the important thing is that the resistance values in relation to each other are correct. With this design, adjustment can be executed simply by comparing the resistance between two buttons in one switch with the resistance between first and last button in the next switch. These values should be equal.

In adjusting or in comparison between two resistances that are nominally equal, the double potentiometer should offer the most accurate method of measurement, at least for resistances that can be loaded with a few volts. The two resistances are coupled in series and are fed with current of suitable intensity. The potential tapping is connected to E_1 and E_2 on the potentiometer and the switch is thrown until the galvanometer indicates zero. If the zero galvanometer has sufficient sentitivity the tension drop over each resistance can be obtained with seven figures, *e. g.*, 1.052461 and 1.052462 respectively. In this example, therefore, the relative difference between the two resistances is 0.0001 %. For this measurement the resistances of the potentiometer do not require to be adjusted with equivalent accuracy. For both measurements there are, of course, used the same resistances in the potentiometer, with the exception of the resistances which correspond to the last figures.

Construction

Fig. 5 shows a picture of the potentiometer. The measurement tensions E_1 and E_2 are adjusted by the 6 + 6 large knobs. Reading is done from figures to be seen in holes on the cover plate. Each knob can be set in 11 positions, numbered 0—10. Beside the pole screws E_1 and E_2 there are two tumbler switches by which the measurement tension can be increased by 1 V. This position is marked + 1 V. By means of the tumbler switch furthest to the left the two measurement tensions are connected in alternately.

The standard cell is connected to the two terminals furthest to the right. As the standard cell's tensions may be of different values, it must be possible to set these by switches, which in Fig. 4 are indicated by N_1, N_2 and N_3. Each switch has eleven positions, designated 75—85, corresponding to a standard cell tension of 1.0175—1.0185 V. The auxiliary current is regulated by the 3 × 3 small knobs at the top. The standard cell is connected into the respective circuits by three press-buttons marked N. The zero galvanometer is connected to the terminals at top left, its sensitivity being regulated by a knob marked R_G.

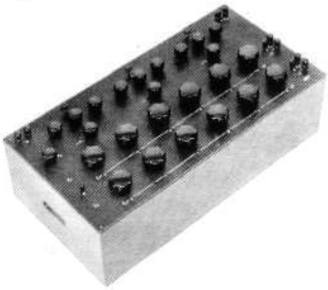


Fig. 5
D. C. potentiometer type YPL 10

X 4437

At the back of the case is a hatch inside which are placed the three auxiliary current batteries. These consist of dry cells of 1.5 V which, with the load in question of 1 mA, have a life of 1 year.

New Electric Interlocking Plant for Stockholm Tramways

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U.D.C. 656.257: 656.4

With the addition of the Stockholm Tramways' new suburban line to Ängby and the new maintenance depot at the Alvik tram station, this station has attained an imposing size in respect of traffic. The tramcars or tramcars with trailers at Alvik per day of traffic is about 900 and in rush hours the number amounts to about 90.

L M Ericssons Signal AB supplied in 1945 for this station an interlocking plant, the technical construction and operation of which is described in the following article.

During the month of October 1945 a new signal plant was taken into service on the Stockholm Tramways. The plant is located at Alvik, which is the junction station for the western suburban lines: the Nockeby line, the Ulvsunda line and the Ängby line. Close to the station is the Company's new tramcar depot, the Bromma Hall, and also a return loop used by some tramcar sets to and from the depot area. At certain times of the day, when car sets drive in and out while the ordinary tramway traffic is proceeding, the traffic is particularly dense and this together with the form of the track area with several level track crossings, a large number of points, right-hand traffic in the depot area (as against left-hand traffic customary for all road traffic in Sweden) etc., provides the reason for a large interlocking plant for the area. The plant now put into service was supplied by Signalbolaget, which company also collaborated in the work of fitting.

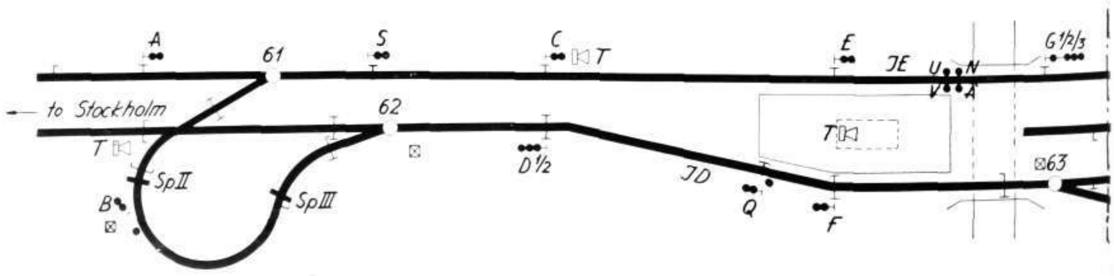
A centrally located interlocking machine supervises an area mainly comprising the return loop at Traneberg, Alvik station and station yard, the junction points for the three suburban lines, certain tracks in the depot area and the track area between these places, see track plan, Fig. 1.

The Interlocking Machine

The interlocking machine, an electrical relay interlocking machine, is housed in a separate signal cabin of three stories, erected close to the station, see Fig. 2. In the basement the relay room has been arranged, constructed as an air-raid shelter. The relays, transformers, rectifiers, cable leads and the greater part of the fuses of the plant have been installed here. The relays

Fig. 1 X 7399
Track lay-out of the signal plant at Alvik

- ⊟ signal cabin
- ! colour light signal
- ⊞ pattern light signal
- • pedal contact
- ☎ telephone
- + scotch block
- ⊠ local switch



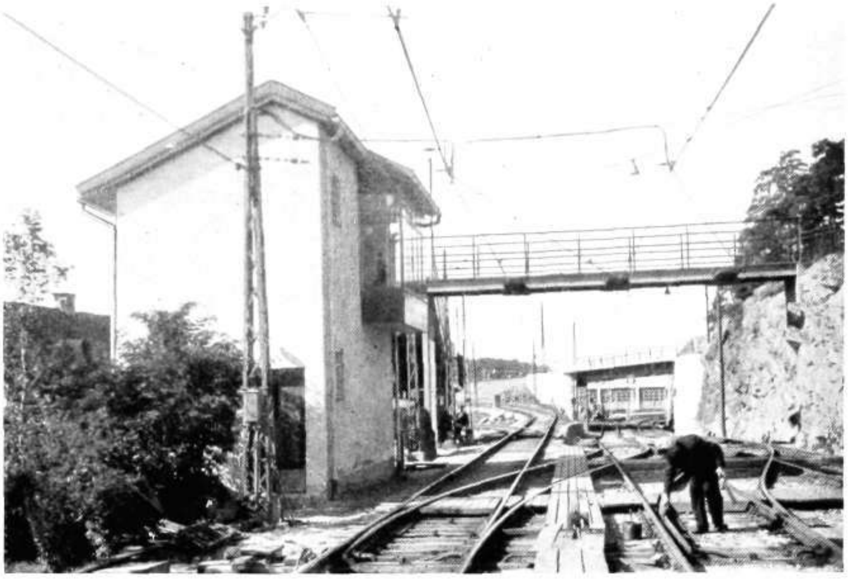


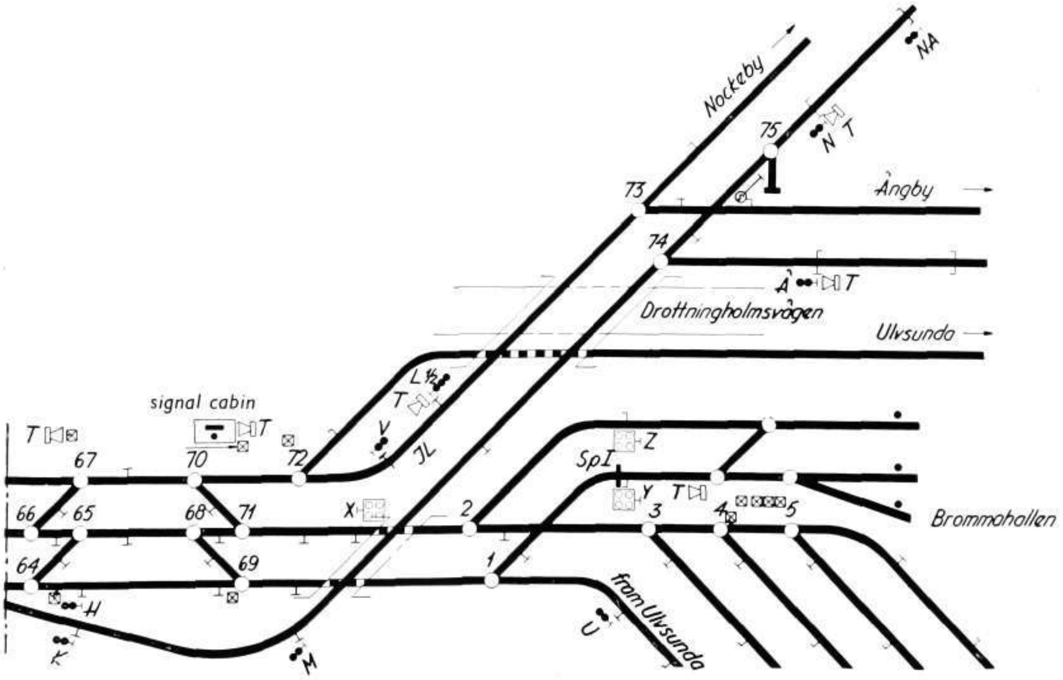
Fig. 2 X 6136

Exterior view of the signal cabin at Alvik

in the background the entrance track to the Bromma Hall

are arranged on a relay shelf with built-in wire conduits, see Fig. 3. The cables are led from a separate cable space below the detachable floor up to the cable boxes placed on the lower part of the relay shelf. The relay room has no heating arrangements as the heat loss in the electric apparatus is quite sufficient to maintain adequate temperature on the premises. From the relay room the electric junction lines are carried in wire conduits through the middle floor, which comprises a room for the signal maintenance men and a small boiler-room, up to the control room on the top floor. At the side looking out on the tracks this top room is built out with glass walls to provide a good view over the station track area.

In the control room the interlocking machine, of press-button type, is set up on a desk at which the operator sits, see Fig. 4. The interlocking machine is provided with press-buttons for operating the signals and points, block lamps for the tram routes and tumbler switches by means of which connecting over to local operation can be made for certain of the points, Fig. 5. Press-buttons for emergency release of blocked tram routes and points are provided with



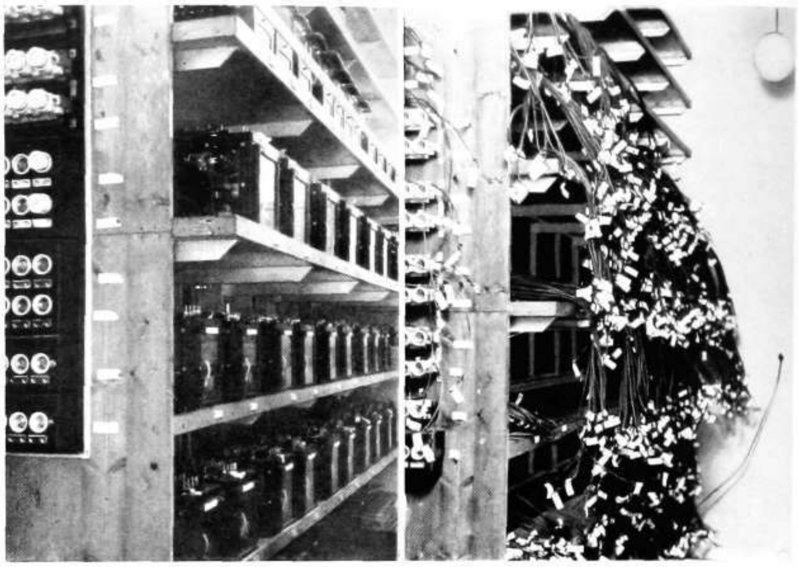


Fig. 3 X 6137

Interior of the relay room

with the plant's relays, transformers, rectifiers and fuses; left, after completion; right, during fitting

seals. In one cupboard of the desk the automatic plugs and fuses for the point machine circuits are stored so that the operator in case of need can reconnect the current without calling for the maintenance man.

Behind the desk, above the interlocking machine, the illuminated track diagram, Fig. 6, is placed on a cupboard. (This gives the signals and points in diagram.) Signal pictures, point positions and state of track circuits are repeated by lamps on the track diagram.

Track Circuits

The track area has been divided into insulated sections, the track circuits. To avoid disturbance from the traction current, which is D.C., the track circuits are fed with A.C. (50 c/s). At several places in the area it has been found necessary to use both rails of a track as return line for the traction current, as this otherwise would cause too great a voltage fall in the rail system. In these cases the track circuit boundaries have been provided with impedance bonds with low resistance for the traction D.C. and high resistance for the track circuit A.C.

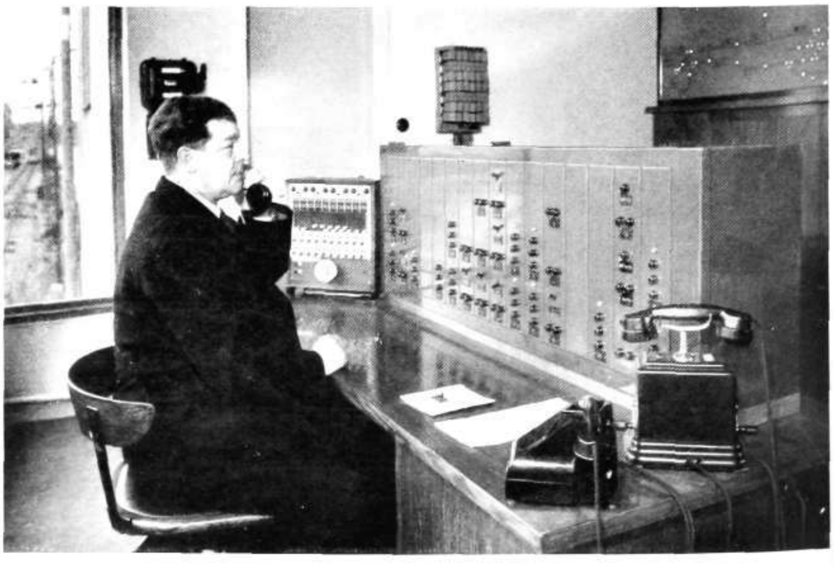


Fig. 4 X 6138

Interior of operators' room

The interlocking machine is on the desk. Above this to the right, a portion of the illuminated track diagram.

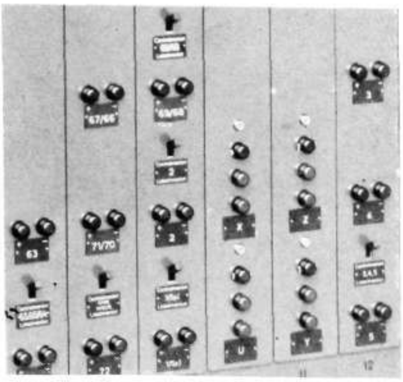


Fig. 5
Picture showing interlocking machine in detail

The main track is divided into track circuits between the signals. In the tramcar depot area the marshalling tracks at entrance are provided with track circuits so located that they indicate when there is room for at least a further three car train on the track concerned. In addition each point or group of points constitutes a track circuit which, when it is occupied by a train, blocks the point or points so that changing of points cannot take place.

As the situation of the track circuits is repeated by way of the track relays in lamps on the track plan, it is possible at any moment to survey the traffic situation in the area covered by signals in the operator's room. The lamp of the track diagram is extinguished when a train is on (shortcircuits) the track circuit.

Points

Nineteen points are comprised in the plant, these being provided with point machines of Signalbolaget's latest type. The points are normally operated from the signal cabin, where the position of points is repeated on the track diagram. Certain of the points, *e. g.*, the transit points in the station area, are coupled up in pairs and changed by a common operation. Most of the points can also be operated by local switches, placed in the vicinity of those points. Local operation can only take place after the operator in the signal cabin has given permission by throwing a tumbler switch on the interlocking machine. There then lights up a lamp on the local switch.

Included in the motor current circuit for the point machines is a contactor with zero tension release. In case of interruption in current this, by breaking the operating relays, prevents the points when the tension is restored from completing any switching started.

In the track from Nockeby there lie catch points with safety track before the crossing with the track to Ängby and the junction points with track from Ängby, see Fig. 7. The catch points are directed to the safety track when the entry signal from Nockeby *(N)* shows danger. Such points are lacking in the track from Ängby. Instead there is to be made a device for automatic train stop in conjunction with the entry signal from Ängby *(Ä)*. This device is under construction.

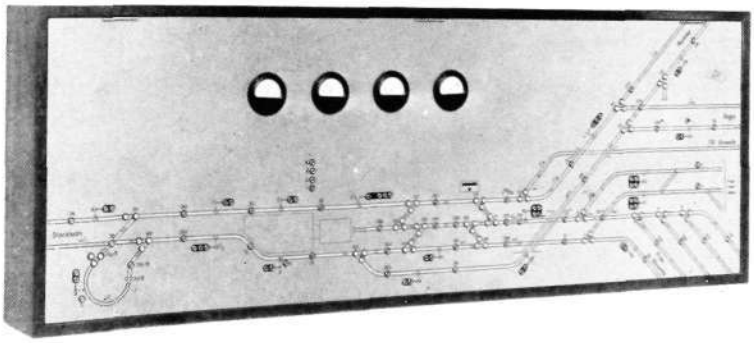


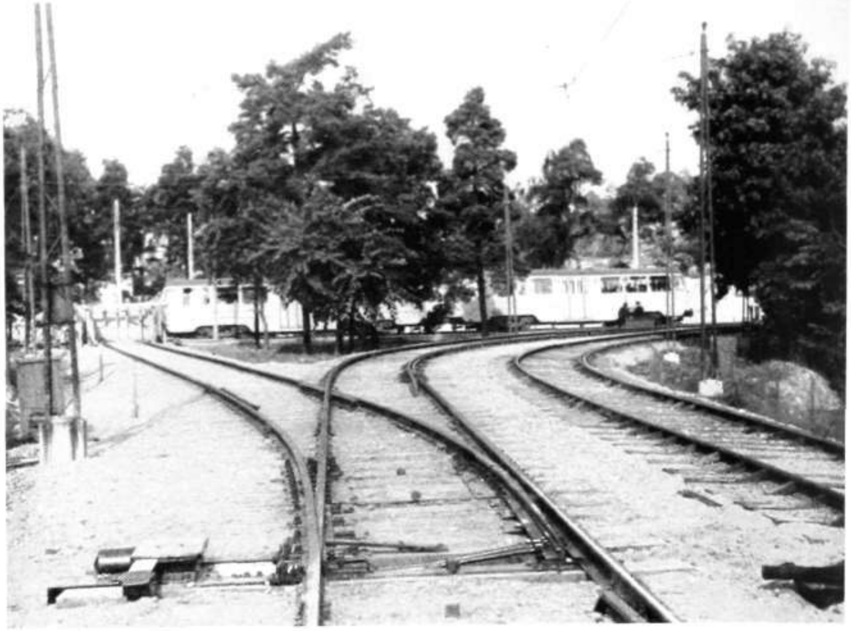
Fig. 6
Illuminated track diagram

On this is reproduced in skeleton the track area with signals and points

Fig. 7 X 6140

Catch points with safety track (left)

where the lines 12 and 11 meet south of Drottningholmsvägen. When complete the points will be covered by gravel



Scotch Blocks

In three places in the area there are located scotch blocks as protection for the main tracks; at the exit from the car depot, at the entrance and exit of the turning loop at Traneberg. The scotch blocks, like the points, are furnished with electric operating devices and are normally operated from the interlocking machine. Two of the blocks are coupled with and operated simultaneously with the respective points in the main track for which they constitute protection. Like the points, the scotch blocks may also be operated manually after permission from the interlocking machine. In the event of fault cranks are used.

Signals

The signals consist of colour light signals and pattern light signals. The colour light signals have a red or green light and one to three green lights to indicate train route. The pattern light signals are of tramway type with four uncoloured lights arranged in a square. The fully automatic signals are purely block signals and cannot be operated from the interlocking machine. The semi-automatic signals act normally as block signals — *e. g.*, the signals A and D^1_2 when the turning loop is not used — but may if necessary be operated from the interlocking machine. The manual signals must always be set from the interlocking machine.

For signalling from the trains to the signal cabin there are *pedal contacts* at various spots. When the driver operates one of these by means of the point-iron, a light corresponding to the contact lights up on the track plan and a buzzer signal sounds. There are pedal contacts for trains outwards to the suburbs — for signalling desired train route —, to trains to the turning loop and for trains from the turning loop or from the depot area.

At all important spots in the area telephones are placed. These are connected to a 20-line plug switchboard in the control room. The switchboard has two circuits to the P.B.X. in the Bromma Hall, through which connection with the public telephone network may be obtained. In addition there is in the operator's room a direct extension instrument to the main tramway exchange at Tegnérgatan in Stockholm.

To supply current for the signal plant, two A.C. services of 3×220 V 50 c/s are led in to the signal cabin. One is connected to the low tension network public mains, the other to a large transformer plant in the Bromma Hall. On failure of the one service the signal plant is coupled over to the other by a switch located in the operator's room. Should both services fail it is probable that the interruption is of such an extent that the traction line current is also lacking.

The new signal plant replaces no fewer than eight smaller plants formerly existing in the area, some of them provisional. Four of these were attended during the greater part of the twenty-four hours. As their functions have now been taken over by the new plant, there is gained not only saving in staff but the advantage that the trams can proceed through the area with absolute safety.

A New Radiogramophone — Svenskradio 1467

C FREDIN, SVENSKA RADIOAKTIEBOLAGET, STOCKHOLM

U.D.C. 621.396.62+681.84

Svenska Radioaktiebolaget, with its new radiogramophone Svenskradio 1467, has put on the market a radio instrument which, boths for its external appearance and owing to its numerous improvements in design, takes up a special class in the line of Svenskradio receivers. Simple but efficient operating devices, the new convenient short-wave tuning by «localized short-wave», perfect sound reproduction and a new rapid-acting switch for getting the local station are special features of Svenskradio 1467, in addition to the new clean lines of the cabinet.

In producing the form of Svenskradio 1467, the designers have naturally followed prevailing ideas of style, without in any way neglecting the demands of sound technique and practical requirements. By renouncing old-fashioned ideas that a radio piece of furniture must of necessity be constructed on the basis of existing furniture styles, there has been successfully produced a unit which, by its soft lines and airy elegance, harmonises extraordinarily well with the agreable sound.

Owing to its relatively small size and its independence of style, Svenskradio 1467, see Fig. 1, is easy to find place for and accommodates itself to any surroundings. It meets the exacting demands which gramophone record collectors, broadcast listeners and dance enthusiasts place on sound quality, sensitivity and volume and it has a new separate station selector for the local station.

It might easily be supposed from the moderate price of this radiogramophone and the small numbers of controls that the producers had provided the fine exterior at the expense of the receiver and the record changer. The description which follows will make it clear that extensive automatising and unusual abundance of details put Svenskradio 1467 right in the front in respect of efficiency and convenience.

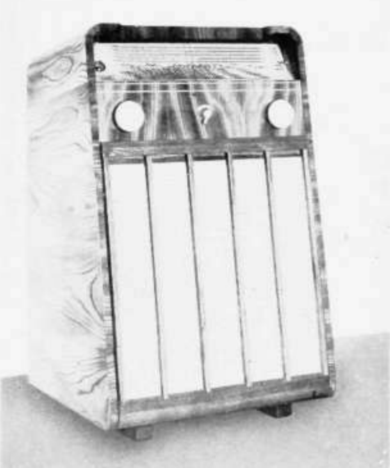


Fig. 1
Svenskradio 1467

X 4376

Receiver

As may be seen from the receiver diagram, Fig. 2, the number of trimming circuits around the frequency changer is dominant. The trimming circuit system for »localized short-wave» has been previously described in conjunction with the presentation of Svenskradio 1454 in Ericsson Review No. 4/1945. On the other hand, the tuning device for local station is based on an entirely new principle.

The aerial and a number of the mixing valve electrodes are cut off in a switch from the normal circuits and instead coupled to a smaller unit located at the top of the chassis. A shaft, with a knob operated from the back of the radiogramophone, extends from this unit. The knob can be turned until the station

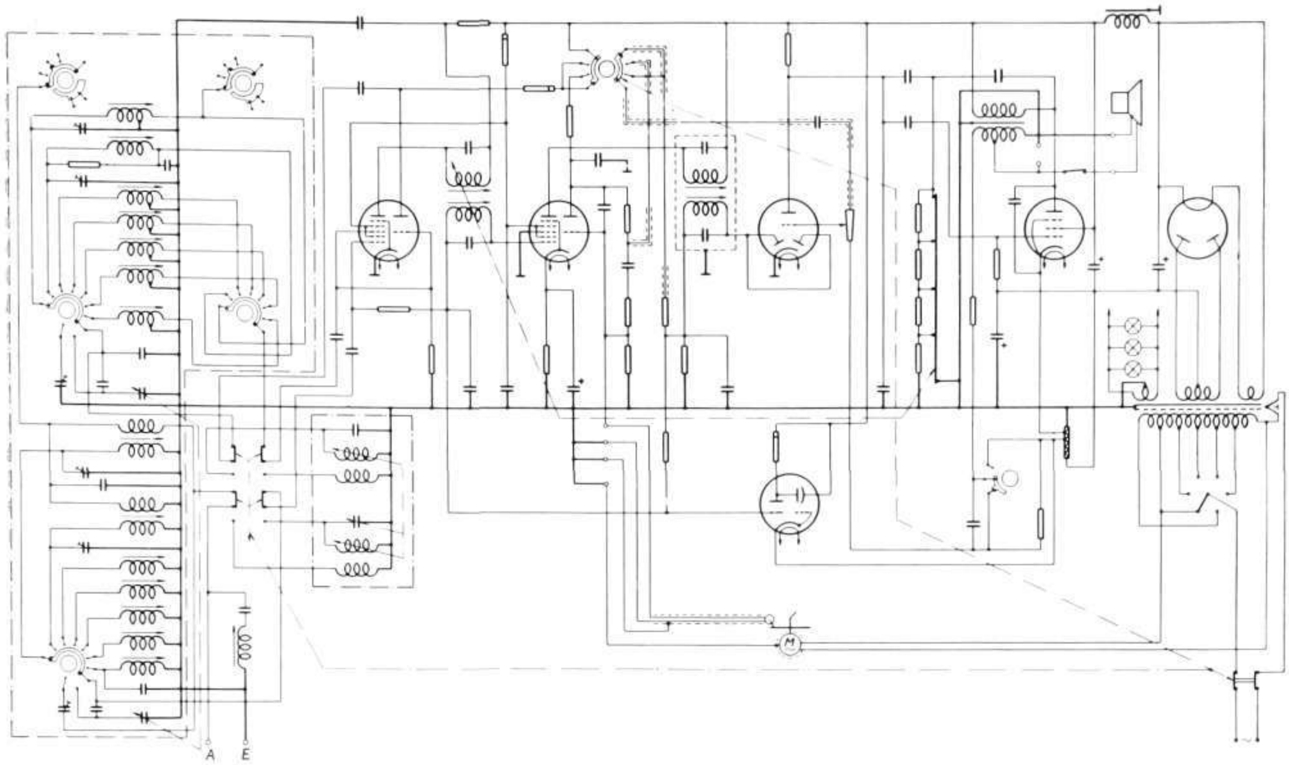


Fig. 2 X 7400
Connecting diagram for Svenskradio 1467 V for A.C.: 6 valves included rectifier valve, 6 tuned circuits; wave-length ranges 16—20, 20—25.8, 25.8—32, 32—42.3, 42.3—51, 194—580, 690—2000 m; output 4.5 W

is tuned in or it can be moved sideways until the selector light is brightest. Through perforations in the back-piece a small scale can be seen, giving the approximate wave-length. The scale shows an abnormally wide wave-length range, 194—1500 m, covering most local broadcast stations of a country. Such a tuning unit for a fixed frequency must be made extremely stable — it is of course set once for all. It must not only attain the highest degree of electrical stability but must also be ensured against inadvertent disturbance of setting.

In principle tuning with iron cores is applied. No difficulty is experienced, of course, in altering the reactance in this way the 9 times required for the oscillator circuit. But difficulty arises with the signal circuit, the reactance of which has to be altered no fewer than 60 times. The simplest manner of solving the problem is by a condenser connected in parallel, with which even faults arising from lack of ganging are corrected. The oscillator coil is built over with a condenser of high quality in respect of stability and with the favourable capacity for this of 470 pF. The length and method of winding also contribute to a maximum of stability.

The cores are driven into the coils by means of a long threaded shaft on which a small knob is fitted. The rise is so dimensioned that the knob is twisted about 25 turns for medium wave. Tuning consequently is easily done and not so susceptible to accidental touch.

In the intermediate frequency amplifier the first filter is variable, so that the strongest station may be reproduced with the largest possible band width, while selectivity also — when required — may be sharpened.

Low Frequency Amplifier

The purpose of the low frequency amplifier is not only to amplify and transform the low frequency tension coming from the detector and the pickup to a power and impedance suited to the loud-speaker. It comprises also a number of correction features, designed to give the characteristic the form accepted by the ear as *true to nature*. Otherwise it would be necessary, to give one example, for a jazz-band to be reproduced with the same intensity and in the same acoustic surroundings as employed in the studio. By means of the physiologically correct sound regulating, the sound will be equally full at all intensities and it is possible with the acoustic selector to modify the sound to a character adapted to the acoustic conditions of the room.

The pickup, of magnetic type, is in the main so constructed that wear of records and scratching from needle will be the lowest possible. The frequency curve given, however, does not comprise any correction for the attenuation of the bass register, applied for the recording of gramophone records. Tones below 250 c/s, in some American records already below 600 c/s, are recorded weaker than the register generally to ensure that the amplitude shall not become too great.

The *requisite correction has been provided in a triode in the intermediate* frequency valve. By means of a strong negative feedback the bass is raised by app. 6 dB per octave below 250 c/s, so that the low-frequency curve will have the same character as with the radio.

Loud-speaker

The wireless is, of course, a transmission system in which sounds become electric currents which after conversion are made to bridge over distance, to be reproduced again as sound after a series of other conversions. The stage of the series most difficult to deal with is without question the transformation of the alternating current into sound. Consequently it is the loud-speaker with its baffle that more than anything else is responsible for the trueness of the sound.

Despite the inclusion of such a quantity of features as are to be found in Svenskradio 1467, there is no detail of construction that has received nearly so much attention as the reproduction of the sound. But the result has been that this radio-gramophone has a sound quality and a volume that surprises even the experts.

Svenskradio's loud-speaker, *HP 1021 F*, is admired in all quarters for its sensitivity and freedom from all resonances injurious to the sound. A contributory cause of the good quality is that the producer has not been deterred by the expense associated with ensuring the high field intensity — over 10 000 Gauss.

Controls

To complete the decorative exterior there are on the front two tastefully *shaped volume and tuning knobs with a small switch between them*. The switch is for rapid change-over to the local station, gramophone, some distant transmitter or — just nothing; as one of the four positions of the switch cuts off the current. The cut-off is therefore very easily accessible and affects neither volume nor tuning.

Record Changer

The record changer, which works entirely automatically, plays in succession or with pauses of varying length, 8 records large and small mixed. The changer may also be made to repeat or proceed direct to the next record and to stop and cut off the current when the last record has been played. The pickup comprises a sapphire that will play thousands of records without replacement. The low needle pressure saves the records and keeps needle scratch to an almost undetectable level. The record changer is very accessible when the lower part of the receiver is pulled out. Control buttons and a knob for setting the intervals are on the left.

Technical data for Svenskradio 1467

	1467 A.C. (A.C.—D.C.)
Sensitivity with 50 mW output	10 μV
Number tuned circuits including the oscillator circuit	6
Wave-length ranges	
short-wave	16 —20 m
	20 —25.8 m
	25.8—32 m
	32 —42.3 m
	42.3—51 m
medium-wave	194—580 m
long-wave	690—2000 m
Length of short-wave scale	1800 mm
Intermediate frequency	467 kc/s
Maximum output	4.5 (4) W
Power consumption	62 (85) W
Starting up time	15 (20) s
Loud-speaker	HP 1021 F
Effective cone area of loudspeaker	300 cm^2
Tone control — band width regulating	yes
Acoustic selector	yes
Radio-gramophone — local station switch	yes
Automatic record changer with sapphire	yes
Tapping for extra loud-speaker, 20 ohms	yes
Adjustable for main tensions numbering	6 (5)
Valve Equipment	
Mixing valve	MECH 21 (6J8GM)
Intermediate and low frequency valve,	MECH 21 (6J8GM)
Detector and low frequency valve	6Q7GM
Output valve	6V6G (25L6G)
Indicator valve	6UG5G
Rectifier valve	5Y3G (25Z6G)
Scale illuminating lamps	three 6.5 V; 0.15 A
Dimensions	
Height	875 mm
Width	536 mm
Depth	470 mm
Weight	
Apparatus with valves, net	37 kg
Apparatus complete, packed	49 kg

New L M Ericsson Exchanges 1945

During 1945 the following exchanges and switchboards on the L M Ericsson system with 500-line selectors were put into service:

town	exchange		number of lines
Tirana, Albania			480
Mendoza, Argentine	Main exchange	(extension)	500
Parana, Argentine		(extension)	1000
Ekenäs, Finland		(extension)	100
Guatemala City, Guatemala	P.A.B.X.		300
Brescia, Italy		(extension)	500
Forli, Italy		(extension)	500
Venice, Italy	Central	(extension)	1700
Venice, Italy	Lido	(extension)	300
Venice, Italy	Mestre	(extension)	500
Vercelli, Italy		(extension)	500
Chapultepec, Mexico		(extension)	500
Victoria, Mexico		(extension)	1500
Vera Cruz, Mexico		(extension)	500
Trondheim, Norway			9000
Bollnäs, Sweden		(extension)	500
Borås, Sweden		(extension)	2200
Göteborg, Sweden	4 P.A.B.X.		240
Göteborg, Sweden	2 P.A.B.X.	(extension)	80
Kristianstad, Sweden			5500
Stockholm, Sweden	Number call	(extension)	1000
Stockholm, Sweden	Östermalm	(extension)	500
Stockholm, Sweden	Hässelby		1000
Stockholm, Sweden	Lidingö vst	(extension)	4000
	Brevik	(extension)	700
	Skärsätra	(extension)	700
Stockholm, Sweden	Lännersta		1500
Stockholm, Sweden	Tureberg	(extension)	1000
Stockholm, Sweden	11 P.A.B.X.		760
Stockholm, Sweden	P.A.B.X.	(extension)	500
Various places, Sweden	10 P.A.B.X.		1860
Various places, Sweden	P.A.B.X.	(extension)	270

During 1945 the following exchanges and switchboards with 100, 25, and 12 line selectors have been delivered. Extensions to existing plants are not included in the figures.

	number	number of lines
Exchanges with 100 line selectors	28	3960
Switchboards with 100 line selectors, system, AHD	12	950
Switchboards with 25 and 12 line selectors, system OL	173	4611

The exchanges on British Post Office system opened during 1945 by Ericsson Telephones Ltd., London—Beeston, and the exchanges on the Rotary system put into operation by Société des Téléphones Ericsson, Colombes, are not included in the figures. Particulars of there will appear in a future number of Ericsson Review.

U.D.C. 621.395.44:621.311

ROHDE, SVEN: *New Carrier Frequency Systems for Telephony and Remote Metering and control on Power Lines.* Ericsson Rev. *23* (1946) No 1 pp. 2—34.

Power distribution undertakings need rapid and reliable long distance communications. This requirement has been intensified by the increase of collaboration between enterprises, the great growth in number and size of power stations and the still longer distances of transmission. Modern carrier frequency technics now enable the power lines themselves to be used for this transmission of speech and signals. The fact that a single carrier frequency channel can be employed for many different transmission purposes such as telephony, remote metering and control, teletyping and selective line protection, makes it possible to reduce the costs for each communication to such an extent that carrier frequency transmission on power lines may be economical even on short distances.

In the article an account is given of the economical and technical essentials of carrier frequency transmission, the carrier frequency systems for power lines of LM Ericsson's make are described and the planning of carrier frequency communication networks is treated briefly.

U.D.C. 621.317.733

HOLMQVIST, SETH: *Direct Current Potentiometers.* Ericsson Rev. *23* (1946) No 1 pp. 35—37.

The D. C. potentiometer described in the article has been developed by LM Ericsson's Mätinstrument AB (Ermi). It is partly based on new principles whereby it can be given a double construction, thus taking the place of two separate potentiometers such as are necessary for, e. g., wattmeter control. As the transition resistance in the switches does not affect the measurement figure, great accuracy can be ensured and by means of a special device the restistance figures can conveniently be adjusted to correct values.

U.D.C. 656.257:656.4

ANCKER, OWE: *New Electric Interlocking Plant for Stockholm Tramways.* Ericsson Rev.*23* (1946) No 1, pp. 38—43.

With the addition of the Stockholm Tramways' new suburban line to Ängby and the new maintenance depot at the Alvik tram station, this station has attained an imposing size in respect of traffic. The tramcars or tramcars with trailers at Alvik per day of traffic is about 900 and in rush hours the number amounts to about 90.

LM Ericsson's Signal AB supplied in 1945 for this station an interlocking plant, the technical construction and operation of which is described in the article.

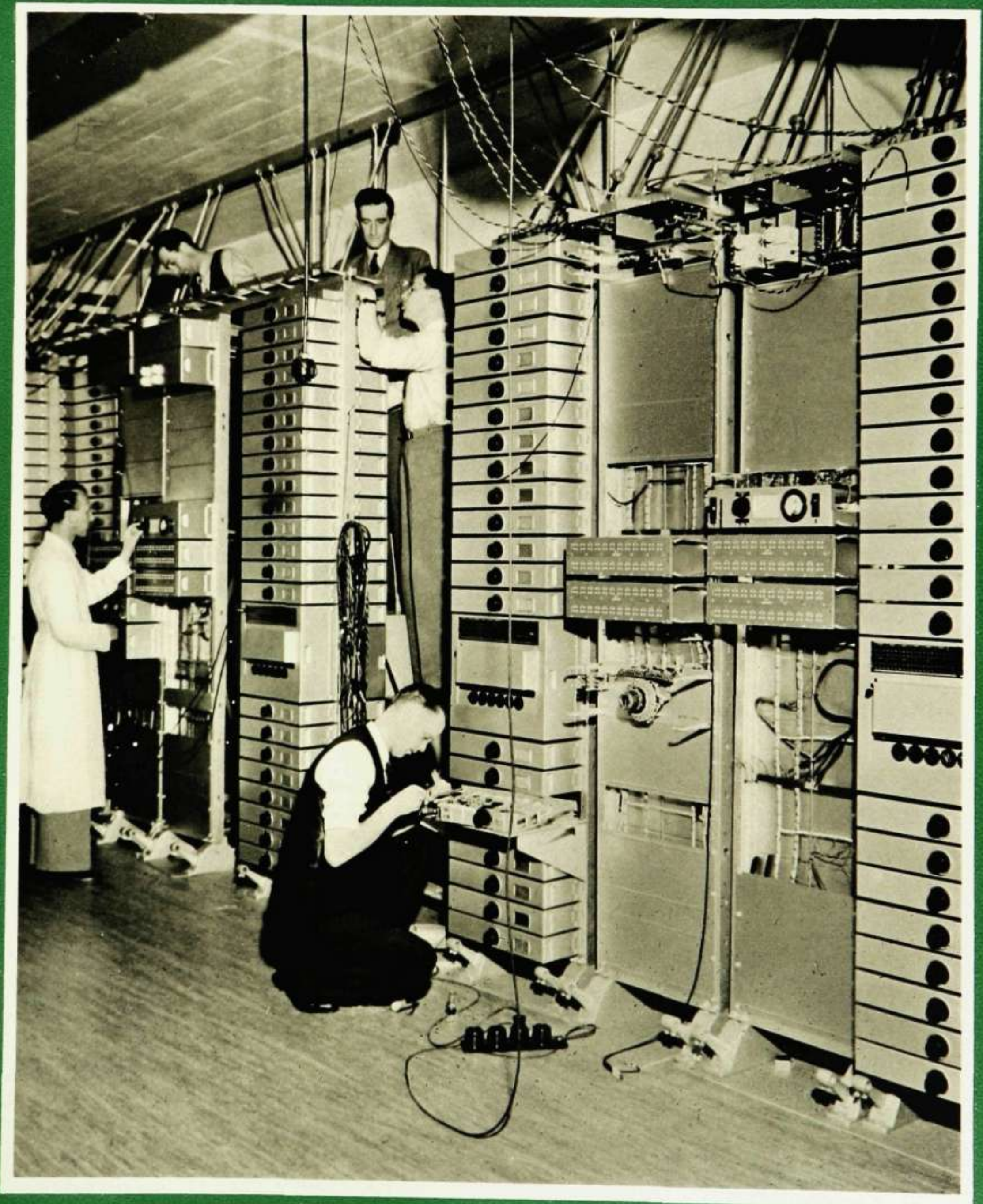
U.D.C. 621.396.62+681.84

FREDIN, CURT: *A New Radiogramophone — Svenskradio 1467.* Ericsson Rev. *23* (1946) No 1 pp. 44—47.

Svenska Radioaktiebolaget, with its new radiogramophone Svenskradio 1467, has put on the market a radio instrument which, both for its external appearance and owing to its numerous improvements in design, takes up a special class in the line of Svenskradio receivers. Simple but efficient operating devices, the new convenient short-wave tuning by »localized shortwave», perfect sound reproduction and a new rapid-acting switch for getting the local station are special features of Svenskradio 1467, in addition to the new clean lines of the cabinet.

Ericsson
LM

Ericsson Review



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Three-Channel Carrier Telephone System for Open-Wire Lines

T BOHLIN, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

U.D.C. 621.395.44

The three-channel system is the classic solution of the problem of high grade carrier telephone communication over long distances. The teletechnician possesses experience of nearly a quarter of a century's service of these systems, and it may with good reason be said that the systems of this type hitherto developed as a rule have well met the technical as well as the economical requirements that have been made upon them. Growing demands as well as steady improvements of both electron valves and other elements used in carrier technics, however, justified a thorough revision of the three-channel system. The new system built by L M Ericsson and completed in 1939 is of entirely new design. Installations with this new system have now been in satisfactory use during several years at different places. A description in detail of the system is given in the following article.

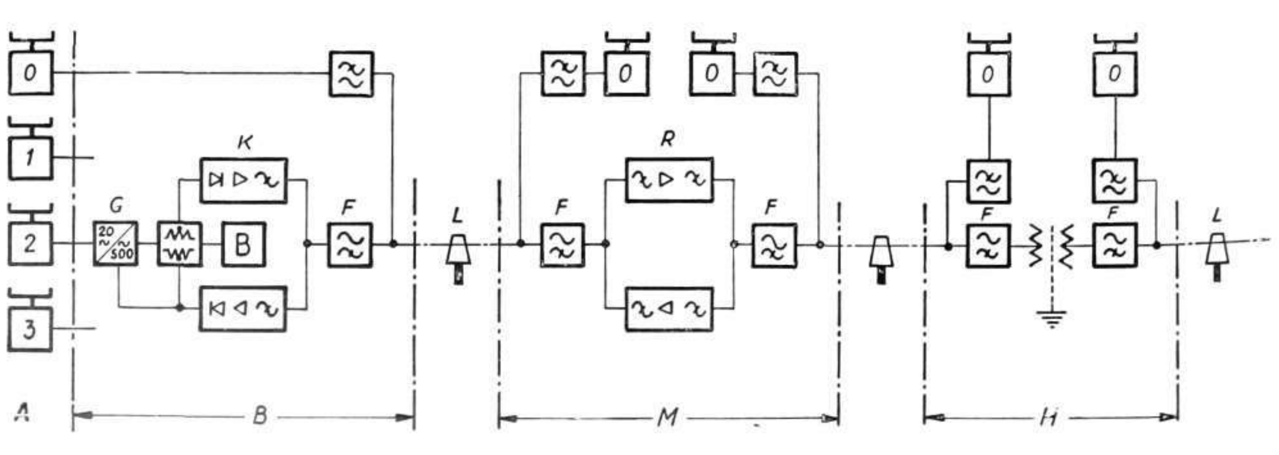
LM Ericsson's new three-channel telephone system for open-wire lines offers, as the name implies, in addition to the physical circuit three additional telephone channels. With its various possibilities of application it provides economically as well as technically good solutions of numerous traffic problems under very different conditions; it is suitable for circuits from about 100 km up to several thousands of km in length. For shorter distances up to 300—500 km terminal equipment only is required, but when longer distances are to be covered intermediate repeaters are inserted with appropriate spacing. Several systems can without inconvenience work on the same pole line. Especially suitable is this system as a skeleton for the telephone network in countries of large extent and comparatively sparse settlement, where for economical and other reasons the laying of underground cables to any great extent is out of the question and where the commercial life and the administrative machinery are concentrated to a few not very large centres.

This system is furthermore well suited for solving more exacting, special tasks, e. g. in railway telephone networks or along other long transport routes carrying heavy traffic etc. With its comparatively large repeater distances and its in general all-automatic level regulation a minimum of maintenance

Fig. 1 X 7366

Diagram of terminal, intermediate repeater and high-frequency shunt

A	subscriber
B	terminal
F	line filters
G	voice-frequency ringer
H	high-frequency shunt
K	channel and amplifier equipment
L	open-wire line
M	intermediate repeater
R	amplifier equipment
0	physical circuit
1, 2, 3	carrier circuits



staff is required. It is designed to work on open-wire lines and is not suited to be used on long cable stretches, for which technically and economically more suitable systems have now been designed. On the other hand, occasional cables across water-ways or lead-in cables do not present any difficulties, although sometimes they require matching net-works or loading coils. Cables however cut down the geographical range considerably.

Fig. 1 shows in a greatly simplified diagram how the terminal and the intermediate repeaters are laid out and connected to the line and the subscribers. Each channel uses — reckoned from the fork side — a frequency band of 300—2700 c/s. Transmission and reception, which take place on different frequency bands, employ the whole of a high frequency band of from about 6 kc/s to about 30 kc/s. The communication circuits obtained are of high quality. The overall attenuation from fork to fork is ± 0 neper, maintained constant within ± 0.1 neper practically independent of the length of the circuit, providing automatic level regulation is used. Modulation and demodulation is performed with copper-oxide rectifiers. The carrier and one of the side bands are suppressed and the carrier oscillators are synchronized manually. A 500 c/s tone is used for signalling. The channels can also be worked in four-wire connection, the input level then being — 1.5 nepers and the output level + 0.5 nepers. The input impedance is, two-wire as well as four-wire, 600 ohms ± 4 %.

The phase velocity of the open-wire line is high, nearly 300000 km/s, and the propagation time for a pair of terminals from fork to fork on the voice-frequency side does not exceed 3 ms in the middle of the band. For a circuit of 300 km in length for example, a propagation time of about 4 ms can be reckoned with and for 1 500 km 8 to 10 ms. The difference in propagation time between the middle and the edges of the band does not exceed 2 ms and the system is therefore well suited for transmission of voice-frequency telegraphy. Up to 18 telegraph channels per telephone channel can be worked.

The recommendation laid down by C.C.I.F. that internal crosstalk within the system should be low has been fulfilled, as have the other requirements stipulated by C.C.I.F. for carrier systems of this type.

Lines and Line Attenuation

The usual open-wire lines of copper or bronze, twisted or transposed — in the latter case with not too large a distance between the transposition points — usually provide, even in their original condition and in any case after fairly simple preparations, satisfactory transmission properties within the whole of the required frequency band. Twisted steel-aluminium wires as well as steel-cored copper wires of good quality can also be used. Lines entirely of iron may be regarded as quite unsuitable.[1]

The line attenuation is appreciably higher for high frequency currents than for currents within the voice-frequency range. The attenuation depends not only on the specific resistance of the line material but also on the distance between the line conductors in the profile, the number and the quality of the insulators, the material of the insulator pins and cross-arms and on some other essential details of construction. The attenuation increases with the frequency from about 4 mN/km for 4.5 mm wires at 6 kc/s to about 15 mN/km for 2.5 mm wires at 30 kc/s. In wet weather, fog and rain, the attenuation increases, and this increase is particulary noticeable with types of lines where the crossarms and sometimes even the insulator pins are made of wood. Lines with crossarms and pins of iron and insulators of borosilicate (pyrex) glass are the least affected by dampness. The attenuation for a few types of lines

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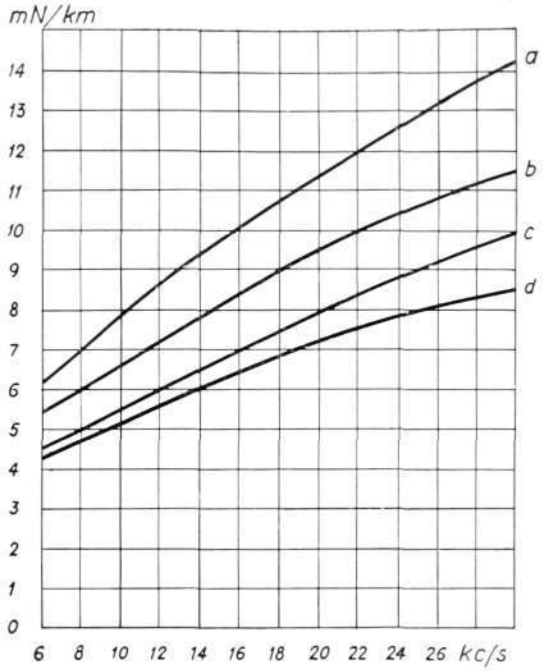
[1] An investigation of the usefulness of steel-cored copper wires was carried out by W Klein and is related in TFT 31/1942, p. 210.

Fig. 2 X 6022

Attenuation curves for different types of lines

I line with crossarms of wood, insulators of alkali glass, wire 3.25 mm copper, 25 pairs of insulators per km, wire spacing 30 cm; plain transposed line
  a wet weather
  c dry weather

II line with crossarms and pins of iron, insulators of porcelain, wire 3 mm copper, 20 pairs of insulators per km, wire spacing $40 \cdot \sqrt{2} = 56.5$ cm; twisted line
  b wet weather
  d dry weather



in dry and wet weather can be read from the curves in Fig. 2. Wet snow and ice — frost — multiply the attenuation.

Data for calculating the attenuation of open-wire lines at high frequencies are given by the author in the Ericsson Review No. 1/1937, p. 27—31.

Range of Distance

Interference due to external sources are always induced in open-wire circuits. Their origin is very varied; the most powerful come, as a rule, from long-wave radio transmitters for intercontinental traffic. Occasionally high frequency interferences emanate from power lines, and finally atmospheric disturbances and other terrestrial currents are responsible. If the interference at the end of a telephone line is measured with a selective instrument which only registers voltages within a certain narrow frequency band with a width of e. g. 100 or 1000 c/s, it is found that the registered value varies between a few powers of ten, when the measuring band is continually moved from lower to higher frequencies. An example of this is shown in the curve, Fig. 3, which reproduces the measured interference at the end of a pair in a quad of about 250 km in length.

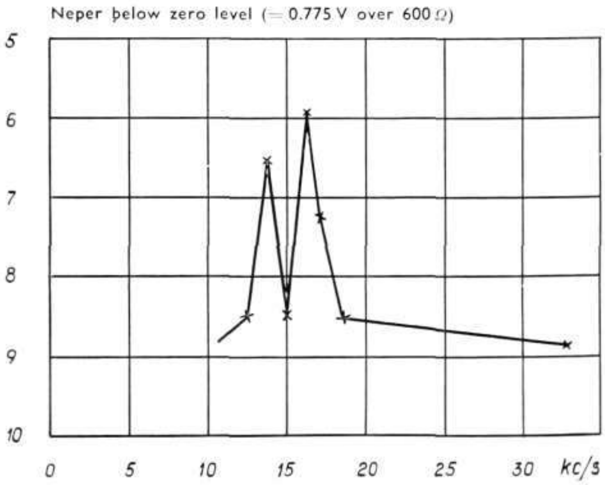


Fig. 3 X 6023

Diagram showing interference at end of a 250 km long double conductor line as a function of frequency

Highest measured values emanate from long wave telegraph transmitters

The interfering currents are demodulated together with the useful currents in the same frequency band and give rise to a background noise in the telephone receiver, the character of which varies with the type and origin of the disturbance. Weak interference of this nature as a rule give rise only to what may be called a »flaw in the beauty» of the circuit in which they appear. Should they, however, become stronger, they reduce the articulation appreciably. The strength of the interference determines, therefore, the lowest value to which the level ahead of the receiver can be allowed to fall without the quality of the circuit being impaired.

On the other hand, the highest level at which the transmitter can work is limited partly by the equipment which can reasonably be used for the generation and control of the transmitted power and partly by considering the crosstalk to other circuits in the vicinity. Experience has proved that on open-wire lines the transmitter should not work at a higher output level than about + 2 N at the beginning of the line, while the input level at the end of the line at 30 kc/s should not fall below — 3 N. In particularly favourable cases the input level may be as low as — 4 N. C.C.I.F. gives the last figure as a limit. In normal cases therefore, a three-channel system can cover a line attenuation of 5 nepers and, under conditions being favourable as regards interference, this attenuation can be increased to 6 nepers. With knowledge of the specific attenuation of the line, the greatest permissible distance between repeater stations in a three-channel system (= range of distance) can be computed. The highest attenuation which can arise under working conditions must be taken as a basis which means that, almost without exception, the value in wet weather must be reckoned with.

This leads to the following approximate figures for the range when copper lines with an overall attenuation of 5 nepers are used:

wire diameter mm	range km
2.5	350
3.0	400
4.5	550

In practice these figures are not attained, as cables in waterways, lead-in cables and other loads on the line cause losses which reduce the range considerably.[1]

Only in very exceptional cases, e. g. when the whole line runs through dry, saltless desert country and one can regard rain as a natural and unavoidable but seldom occurring cause of interruption, can a greater range be exploited on normal lines. On the other hand, cases exist where extra repeater equipment has been installed but only for operation in winter time to compensate for a more or less frequent formation of frost on the line.

Frequency Allocation

It has already been stated that the three-channel system occupies the frequency range between 6 and 30 kc/s and that different frequency bands are used for transmission in the different directions. There is a »lower group» for transmission from terminal A to terminal B and a »higher group» for transmission from B to A. In reality two different systems with different frequency allocation are used, ZAG 10 and ZAG 11, the frequencies of which are staggered in relation to each other, so that the frequency band of the one system lies for the most part in the gaps between the bands in the other. By this means the risk of crosstalk between two systems working in parallel on the same line is appreciably reduced. Fig. 4 a shows the position of the frequency bands in the two systems; arrows indicate the carrier frequencies.

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[1] C.C.I.F. recommends 150, 300 and 500 km for 2, 3 and 4 mm wires respectively. This recommendation is, however, to a certain extent dependent on the prescribed interval between voice-frequency repeaters in two- and fourwire operation and should therefore be treated with a certain reserve.

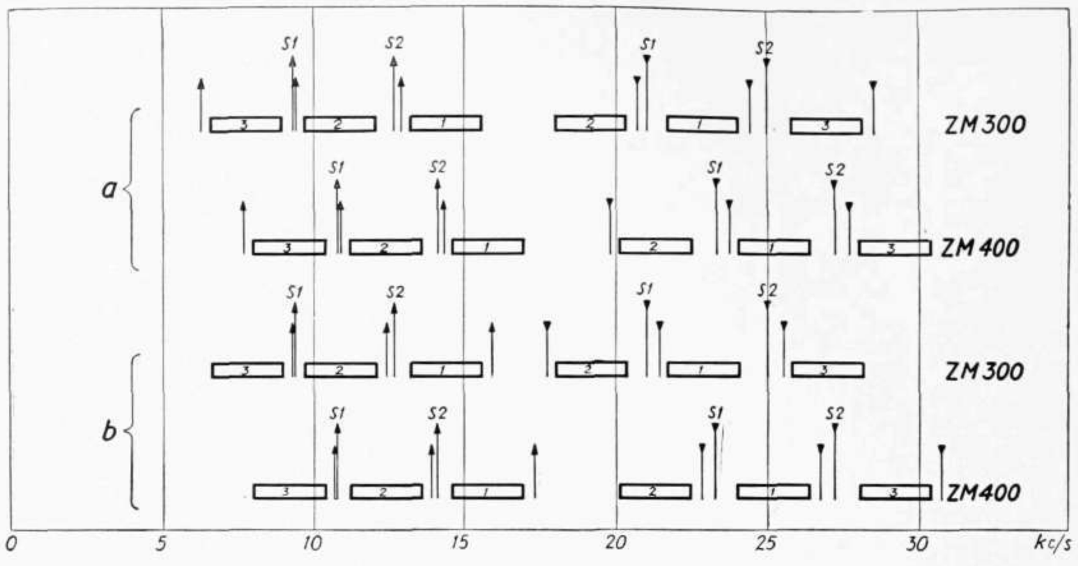


Fig. 4 X 7367

Frequency allocation of three-channel system

a with normal bands

b with inverted bands

Arrows denote carrier frequencies; S 1, S 2 alternative pilot frequencies; lower group transmits from north to south or from east to west (arrows pointing upward); upper group transmits from south to north or from west to east (arrows pointing downward)

If more than two three-channel systems are working in parallel on the same pole line, then obviously pairs of systems must, as a rule, be identical, and a certain risk for crosstalk between them exists. To reduce this risk, the frequency bands on one of the systems can be »inverted», i.e. the carrier frequencies can be shifted to the opposite edge of the bands, resulting in the high and low frequencies of the speech band changing places in the transmitted band. Any crosstalk then appearing will be unintelligible. The new carrier frequencies are included in Fig. 4 b, which otherwise is identical with Fig. 4 a.

It has already been mentioned that the carrier frequencies are suppressed and consequently are only present in the terminals and not on the line. On the other hand, each terminal transmits a pilot frequency, which affects the level regulating equipment on the receiving side. This pilot frequency is, within certain limits, displaceable within the group but is generally placed in the lower group in the gap between channel 1 and 2, and in the higher group in the gap between channel 1 and 3. The alternative pilot frequency allocations S1 and S2 are shown in Fig. 4.

A summary of all frequency bands, carrier and pilot frequencies is given in table I.

If several three-channel systems are to be worked in parallel, the frequency groups of the different systems must, on account of crosstalk, transmit in the

Table 1. Nominal figures of band limits, carrier and pilot frequencies in kc/s

system	group	channel	transmission band	carrier freq.		pilot freq. alternatively within band
				normal	inverted	
ZM 300	lower	1	13.2—15.6	12.9	15.9	9.25—9.45 12.35—12.95
		2	9.7—12.1	9.4	12.4	
		3	6.6—9.0	6.3	9.3	
	upper	1	21.7—24.1	24.4	21.4	20.65—21.45 24.35—25.55
		2	18.0—20.4	20.7	17.7	
		3	25.8—28.2	28.5	25.5	
ZM 400	lower	1	14.6—17.0	14.3	17.3	10.65—10.95 13.85—14.35
		2	11.2—13.6	10.9	13.9	
		3	8.0—10.4	7.7	10.7	
	upper	1	24.0—26.4	23.7	26.7	22.75—23.75 26.65—27.75
		2	20.1—22.5	19.8	22.8	
		3	28.0—30.4	27.7	30.7	

same direction and not against each other. To avoid surprises in this respect in future extensions, it has been made a rule to have the groups working in fixed directions of the compass. Thus the lay-out is always, if possible, made in such a way that the lower group transmits from north to south or from east to west. Terminal A is therefore always put at the northern or eastern end of the line, and terminal B at the southern or western end.

Joint Working Circuits

The lowest transmitted frequency of the lower group is for system ZAG 10 about 6.6 kc/s, and for system ZAG 11 about 8 kc/s. The band below these frequencies down to zero frequency is not called into use for the three-channel system, but is utilized for various other purposes. First and foremost the 0.3—2.7 kc/s band is used almost without exception for carrying the normal physical circuit — generally with the use of two-wire repeaters. As ringing signal for this circuit 20 c/s is used directly, as long as the frequencies below 300 c/s are not used for sub-audio telegraphy, in which case 500 c/s is used for signalling. The range from about 3 kc/s to about 6 and 7.5 kc/s respectively may be used for carrier telegraph transmission of up to 4 and 8 channels respectively in either direction. Finally there are cases where, in system ZAG 11, the whole band between 0.03 and 7.5 kc/s is used either permanently or occasionally for transmission of radio programs. This may as an exception also be done with system ZAG 10, but in this case no frequencies higher than 5.5 kc/s can be transmitted. In these last two cases the physical circuit and the eventual carrier telegraph circuit must of course be disconnected.

The frequencies above the three-channel system range can of course in a similar way be utilized for simultaneous communication with other carrier circuits, but the necessary filters must be included in the additional equipment.

Channel and Amplifying Equipment

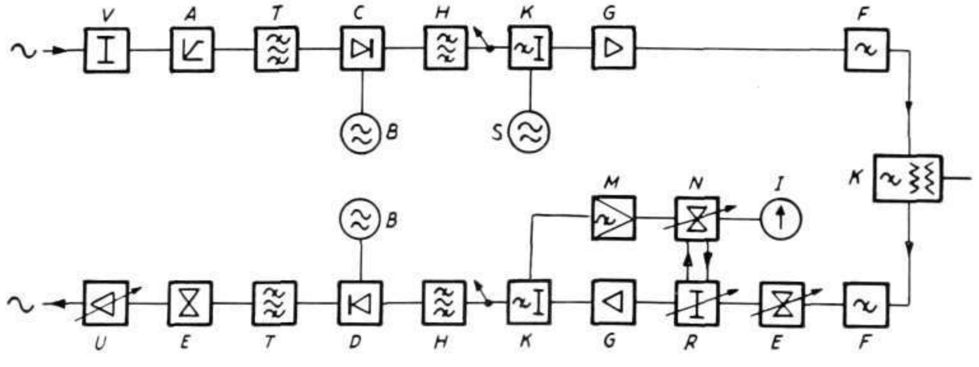
Fig. 5 shows the lay-out of the channel and the common amplifier equipment of a terminal. The transmitter lies in the upper part of the figure, the receiver in the lower part. Starting from the fork — not shown in the figure — the voice-frequency currents pass first through a volume limiter on the transmitter side, the function of which is to protect the transmitting amplifier from being overloaded by near-by loud talking subscribers. After the volume limiter follows a band filter, which cuts out frequencies under 200 c/s and over 2700 c/s. The remaining band is passed on to the modulator, which uses copper oxide rectifiers in conventional ring connection and is supplied with carrier current from an oscillator. After the modulator follows a band filter, which passes the high frequency band with the band limits shown in Fig. 4.

At this point the transmitting band filters of the three channels are connected in parallel through a compensation filter and the currents leaving here now occupy the frequency range of the whole lower or upper transmitting group. They pass through the common transmitting amplifier, the directional filter and the line filter and reach the line.

Fig. 5 X 7368

Diagram of channel and amplifier equipment of terminal

A	volume limiter
B	carrier oscillator
C	modulator
D	demodulator
E	line equalizer
F	directional filter
G	group amplifier
H	high-frequency band filter
I	level indicator
K	compensating filter
M	pilot receiver
N	level regulator
R	regulating network
S	pilot transmitter
T	voice-frequency band filter
U	voice-frequency amplifier
V	pad



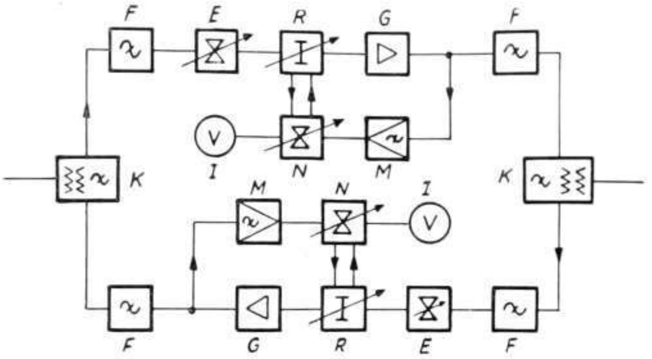


Fig. 6 X 6024

Diagram of amplifier equipment of intermediate repeater

E	line equalizer
F	directional filter
G	group amplifier
I	level indicator
K	compensating filter
M	pilot receiver
N	level regulator
R	regulating network

In the opposite direction the high frequency currents arriving pass from the line through the line and directional filters to the receiving amplifier common for the three channels of the group. Before reaching the receiving amplifier the currents pass through two correcting networks; one fixed line equalizer, the function of which is to equalize the higher attenuation of the line at the higher frequencies, and one varying, which contains devices for taking care of the changes in the line attenuation caused by variations of temperature and weather. The receiving amplifier is connected through a compensating filter to the three receiving band filters, each of which connects to its demodulator with appropriate local carrier oscillator. The voice-frequency currents pass from the demodulator through a voice-frequency filter to be amplified in the channel amplifier before they reach the receiving side of the fork.

The amplifying equipment of the intermediate repeater is in the main the same as that of the terminal, but is of course arranged alike for both directions, Fig. 6. From the line filters the currents for both directions pass through the directional filters, the line equalizers and the regulating networks to the input side of the group amplifiers. The output sides are directly connected to the directional filters.

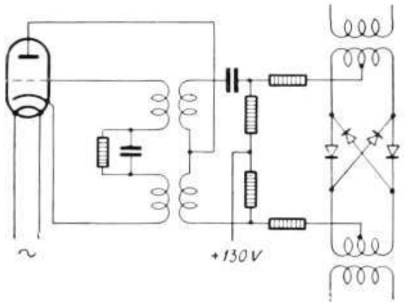


Fig. 7 X 4294

Frequency stable oscillator circuit

Modulator is connected in series with tuning circuit and output transformer is not used

Channel Oscillators

Modulator and demodulator differ only in function and frequency. They are both mounted along with their oscillators on a common panel. The panels of A and B ends are identical, and the unit which works on A end as a modulator functions on B end as a demodulator and vice versa.

The oscillating circuit of the oscillators is connected in such a way, Fig. 7, that the feed-back voltage is practically free from phase shift, which results in the best possible stability. The load — the modulator — is connected in series with the elements of the tuning circuit without the use of an output transformer, which likewise contributes to stability. The tuning circuit itself is temperature compensated, and, to ensure that the compensation functions even during rapid temperature changes in the surroundings, the entire circuit is placed in a heat insulated box, by which means the effect of the different thermic inertias of the elements is eliminated. The same box is used for the oscillators of both the transmitter and of the receiver in the same channel.

One and the same unit can be altered as desired to transmit or receive the upper or lower side band through a simple shift of the carrier frequency from one side of the band to the other.

It is characteristic of the ring modulator that it suppresses the carrier. The condition for this is, however, that all four elements of the modulator are exactly alike. It is not always possible in practice to make them as identical as is required for the carrier to be sufficiently suppressed, but, on the other hand, it is possible by balancing to reduce the greater part of the »carrier leak», using a potentiometer and a small differential condenser, which are connected to the output side of the modulator. Fig. 8 shows two oscillator panels, each of which contains a transmitter and a receiver oscillator.

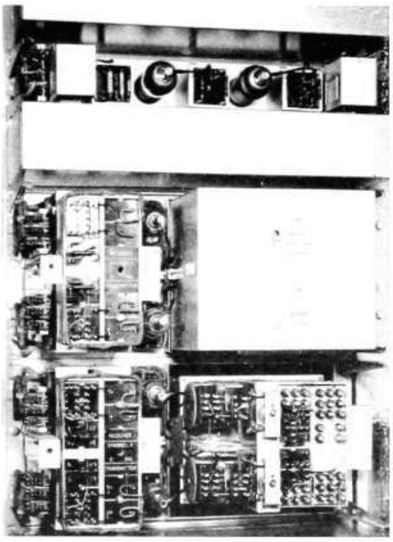


Fig. 8 X 4299

Two oscillator panels mounted in bay

On lower panel the cover is removed showing elements of tuning circuits; balancing device of modulator is placed between and to the left of valves; above oscillator panels, group amplifiers

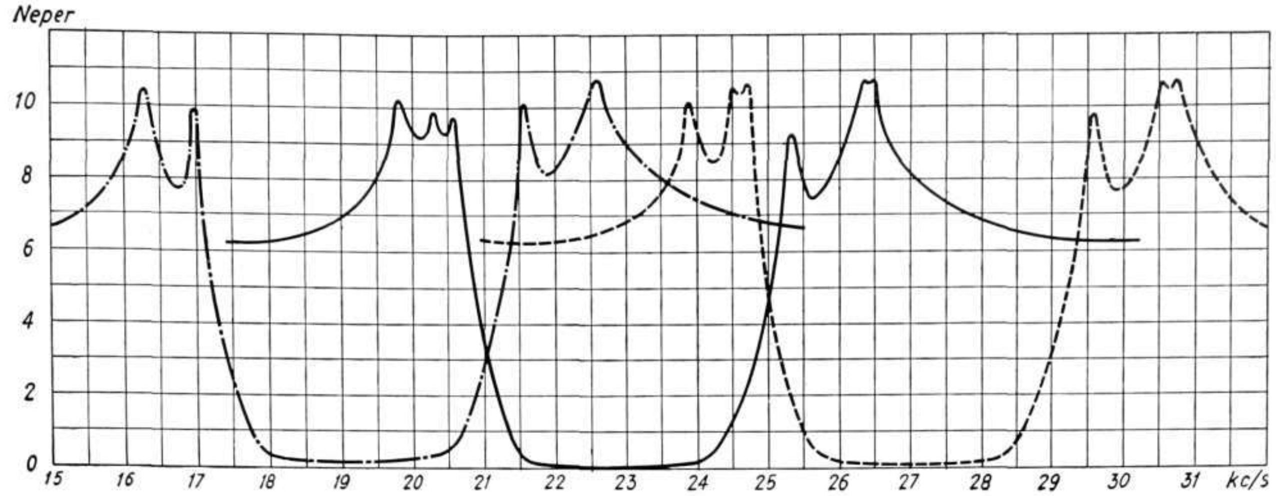


Fig. 9 X 7369
Attenuation curves of band filters in upper group of system ZM 300

Bandfilters

The crosstalk allowed between the speech channels determines the attenuation of the band filters. The attenuation requirements are especially high on that side of the band where the suppressed side band is located. As, however, the carrier frequency can be shifted from one side of the band to the other and as the suppressed side band then follows the carrier, the filters must be designed in such a way that they can without change meet the attenuation requirements regardless of the side the carrier frequency is placed at. The frequency characteristics of the filters are therefore nearly symmetrical around the passed band.

Fig. 9 shows filter characteristics of three of the six bands in system ZAG 10. The band filters used in system ZAG 11 are of the same design but with other cut-off frequencies.

The Group Amplifier

When several speech channels are to be amplified in a common amplifier, this must be free from non-linear distortion, as otherwise crosstalk will occur between the channels. The group amplifier of the three-channel system is of the negative feedback type. This ensures the desired low non-linear distortion, and at the same time a very good gain frequency characteristic and a very good stability in amplification.[1]

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[1] The theory of negative feedback amplifiers is given briefly in Ericsson Review No. 2/1939, p. 46—48.

Fig. 10 X 4295
Harmonics of group amplifier for gain of 6 nepers

Second and third harmonic level as a function of output power

Fig. 11 X 4296
Gain of group amplifier as a function of frequency

a without negative feedback
b normal gain of 6 nepers
c with raised gain

Fig. 12 X 4297
Gain of group amplifier as a function of output power

Fig. 10

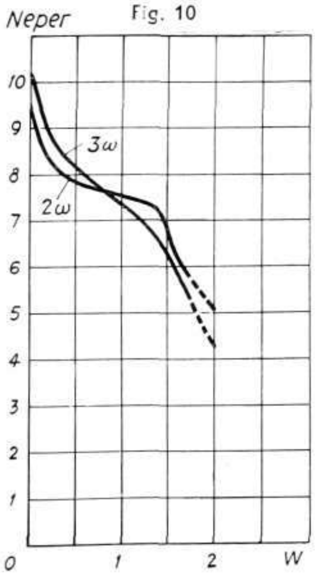


Fig. 11

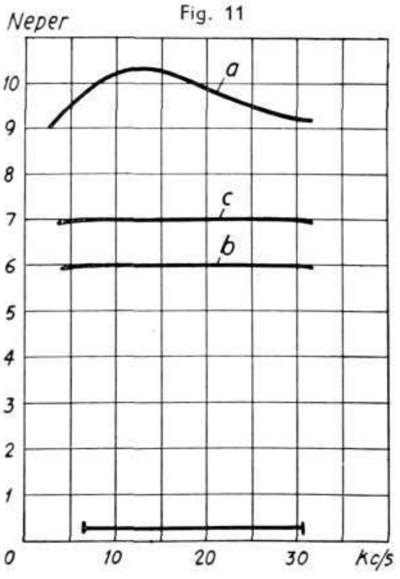


Fig. 12

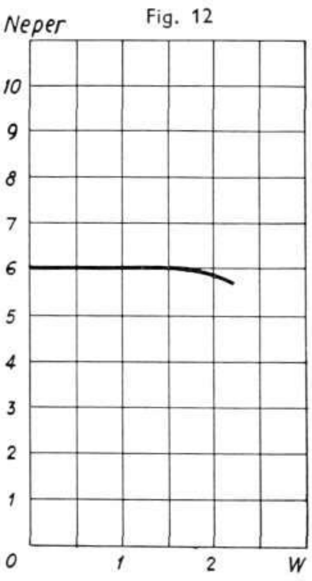


Fig. 13 X 6025
Diagram of group amplifier
Feedback circuit in heavy lines

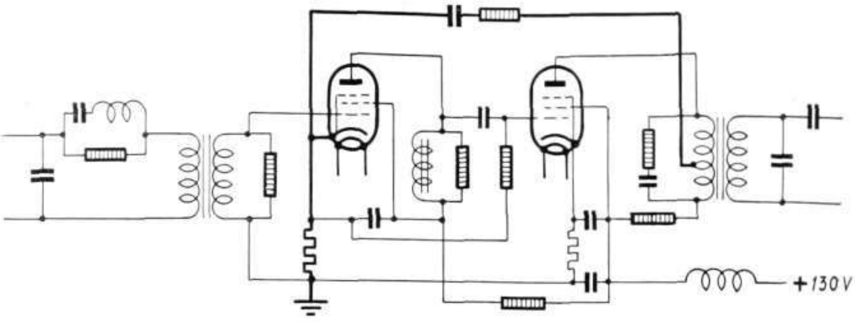


Fig. 10 shows the level of the 2nd and 3rd harmonics in proportion to the level of the fundamental frequency as a function of the power output level. The gain as a function of the frequency is shown in Fig. 11 without and with negative feedback, in the latter case connected to give a gain of 6 and 7 nepers respectively. Finally Fig. 12 shows the gain as a function of the power output level. The amplifier employs two valves; from the diagram in Fig. 13 it may be seen that the negative feedback connection does not include the transformers. Against this, the output and input impedances are corrected with a few complementary elements. The whole amplifier is mounted on an 88 mm panel, Fig. 14. One spare amplifier, to be used for either direction, is mounted on each channel bay.

Equalizing the Line Attenuation

If the total attenuation is calculated for a stretch of line, the attenuation of which at 30 kc/s in wet weather is 5 nepers — that is to say the greatest attenuation the three-channel system normally can cover — the curves in Fig. 15 are obtained. These show that the difference in attenuation for the extreme frequencies in a band group is not inconsiderable, and also that the change in attenuation from dry to wet weather can rise to a considerable value even on a single repeater section.

In order to prevent changes in the over-all attenuation of the speech channels the level ahead of the demodulator must be kept constant, and variable attenuation networks are therefore inserted in the common receiving branch to compensate for irregularities and changes in the line attenuation.

The variation of the line attenuation with the frequency is equalized mainly in the line equalizer network. This contains three units connected in series, which can be set to give an attenuation slope in steps of about 0.25 neper up to maximum 2 nepers in difference between the edges of the received band. This line equalizer is set once for all according to the length and the properties of the line.

The line attenuation changes from hour to hour owing to variations in temperature and weather conditions. These changes are equalized by the regulating network which therefore must be continually varied.

The regulating network consists in principle of a variable, phase-free attenuator, which is inserted on the receiving side and regulates all three

Fig. 14 X 7371
Group amplifier
To the left, panel opened for test; to the right panel in operating position; by cutting strap as arrow points gain is raised from 6 to 7 nepers

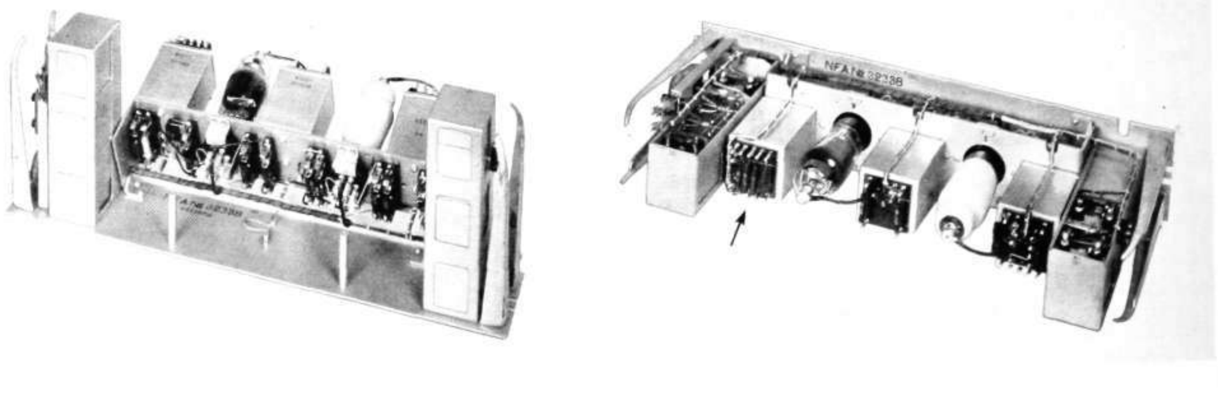
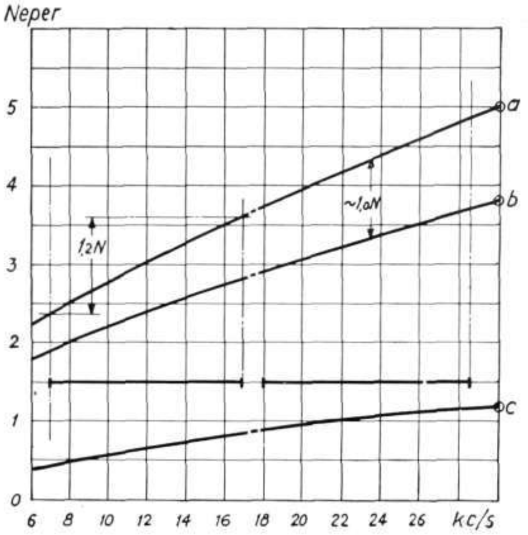


Fig. 15 X 6026

Attenuation curves for a line, which at 30 kc/s in wet weather has a total attenuation of 5 nepers

a wet weather
b dry weather
c = a — b = attenuation change; approximate position of »lower» and »upper» transmission groups are indicated



channels at the same time. Such an attenuator does attenuate all frequencies equally. If however curve c in Fig. 15 is studied closely it will be found that the changes in attenuation are larger at the higher frequencies. In the regulating the network, arrangements are made to take care of this by adding after the network an auxiliary voltage which varies its phase angle with the frequency. The resultant of the auxiliary and the main voltages varies with the frequency and the line attenuation in such a way that the changes of the line attenuation are compensated and the level is kept constant.

The function of this arrangement is seen more clearly from the diagram in Fig. 16. The currents arriving from the line over »I» first pass through the line equalizer and a fixed supplementary pad, and then at the regulating network delivers the voltage $\overline{U}_I$. By a differential transformer the currents are directed into two different branches, of which one is the phase-free network β and the other is the phase-shifting network α. Across the load resistance R the voltages $\overline{U}_\beta$ and $\overline{U}_\alpha$ are present. They compound as shown in the vector diagram Fig. 17 to a resultant $\overline{U}_R$ which can be larger or smaller than the main voltage $\overline{U}_\beta$ depending on the value the phase angle α has at the frequency in question.

When the frequency now rises from the lowest to the highest figure it can have within the band, vector $\overline{U}_\alpha$ will shift from position 1 to position 2 and the resultant voltage $\overline{U}_R$ hence decreases with the frequency from value $\overline{U}_{R1}$, to value $\overline{U}_{R2}$. The attenuation Θ through the regulating networks is derived from the following

$$\Theta = {}^{e}\log \frac{|U_I|}{|U_R|}$$

and increases therefore with increasing frequency.

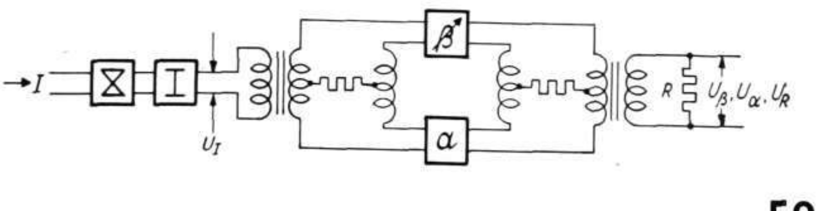
The larger the vector $\overline{U}_\alpha$ is, the more the attenuation will increase for the same change in frequency, which is evident from comparison between a and b in Fig. 17.

In reality the voltage $|\overline{U}_R|$ is, through the varying attenuation β, kept constant at a certain frequency free of choice within the transmitted band, usually for the pilot frequency. This causes the voltage vector $\overline{U}_\beta$ to remain nearly constant when the line attenuation and hence the voltage $\overline{U}_I$ varies.

Fig. 16 X 6021

Diagram showing function of regulating network

α phase shifting network
β variable attenuator
I input side
R load resistance
U_I incoming voltage
U_α, U_β part voltages
U_R outgoing resultant voltage



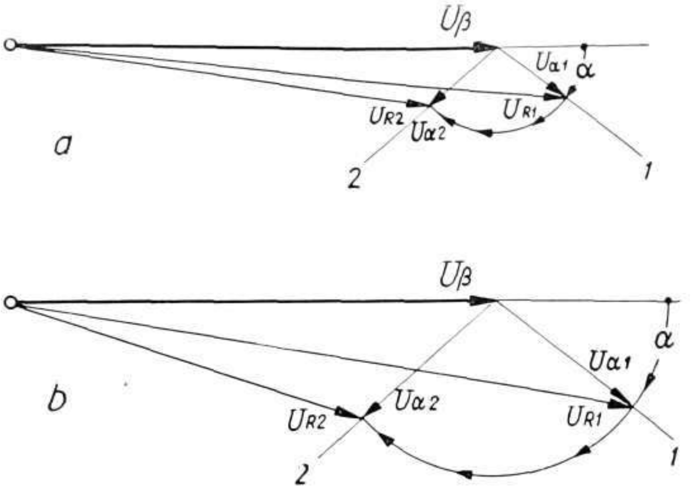


Fig. 17 X 6027

Vector diagram of function of regulating network

- α angle of phase shifting network
- U_α, U_β part voltages
- U_R resultant voltage
- 1 position of U_α at lowest frequency of transmitted band
- 2 position of U_α at highest frequency of transmitted band
- a *in wet weather*; U_α *is small, difference* $|U_{R1}| - |U_{R2}|$ becomes small
- b in dry weather; U_α is large, difference $|U_{R1}| - |U_{R2}|$ becomes large

The currents passing through the phase-shifting network α are, however, not affected by the changes in network β. Hence the voltage $\overline{U}_\alpha$ rises and falls in time with $\overline{U}_r$. When $\overline{U}_\alpha$ therefore is low on account of high line attenuation in wet weather the attenuation Θ becomes almost independent of the frequency, Fig. 18 a. In dry weather, however, when the line attenuation is low, $\overline{U}_\alpha$ is high, resulting in a higher increase of Θ with increasing frecuency, Fig. 18 b.

The attenuation of the regulating network is thus adjusted exactly to the variations of the line attenuation by working one single network. Wire dimensions, wire spacing and type and number of insulators determine, as seen before, the line attenuation to a high degree. With a simple setting of an additional attenuator connected in series with α the regulating network can once for all be adjusted to equalize the slope of any line existing in practice. How the line attenuation, the line equalizer and the regulating network work is shown in Fig. 19, where the condition for dry as well as wet weather attenuation is shown. KN is the line equalizer, which is all the time unchanged.

Fig. 18

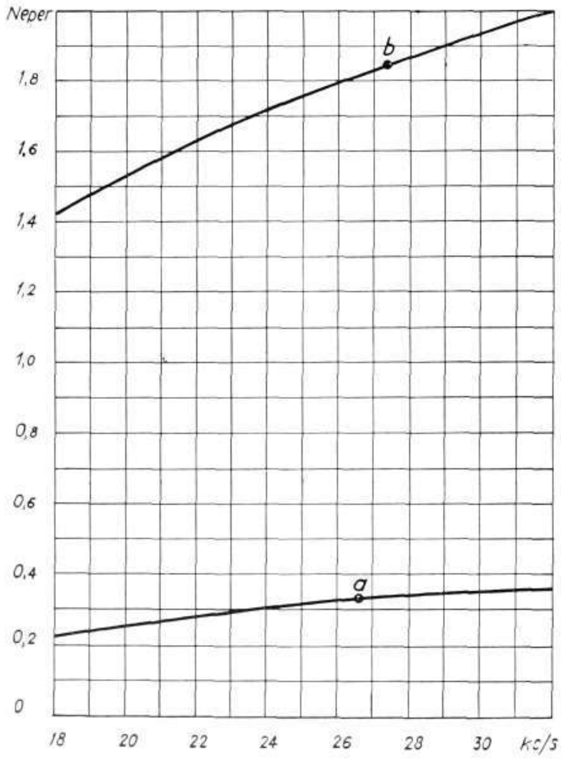


Fig. 18 X 6028

Attenuation of regulating network for upper group

- a set for low attenuation (wet weather)
- b set for high attenuation (dry weather)

Fig. 19

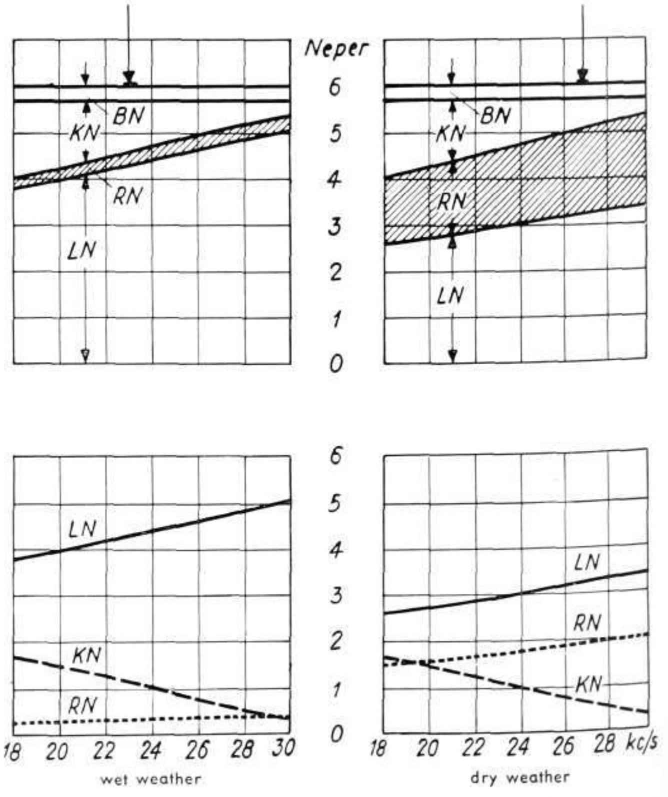


Fig. 19 X 6029

Correction of line attenuation by regulating network and line equalizer in wet and dry weater

- BN loss in filters etc.
- KN line equalizer
- LN line attenuation
- RN attenuation of regulating network

Lower figures show values of different attenuations, upper figures show totals of them

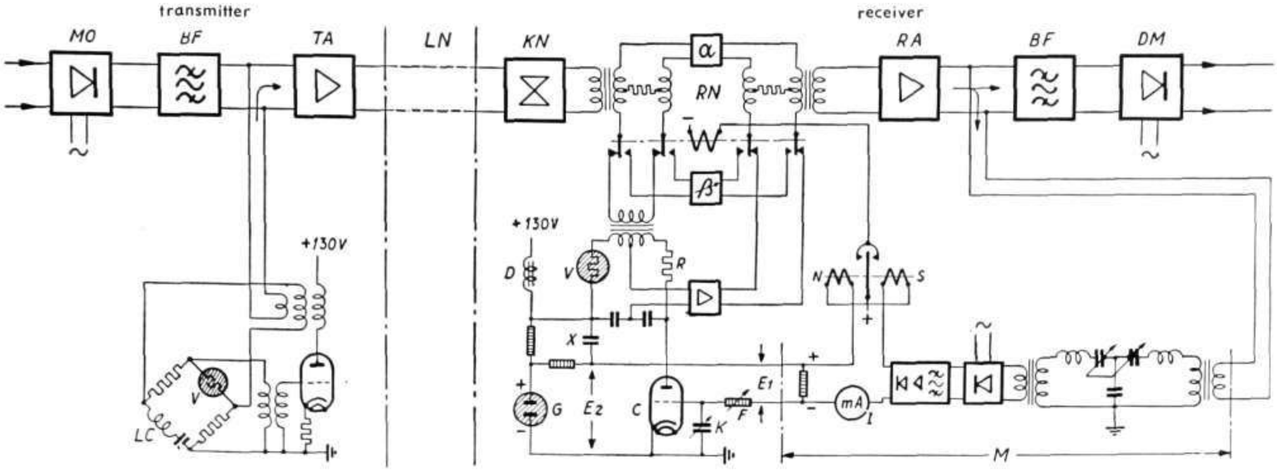


Fig. 20
Diagram of regulating circuit

X 7370

BF	band filter
C	control valve
D	choke coil
DM	channel demodulator
E_1	pilot potential
E_2	comparing potential
F	delay resistance
G	glow lamp
I	indicating instrument
K	delay condenser
KN	line equalizer
LC	tuning circuit
LN	line
M	pilot receiver
MO	channel modulator
R	fixed resistance
RA	receiving group amplifier
RN	regulating network
TA	transmitting group amplifier
V	current-controlled resistance
X	compensating condenser

LN is the line attenuation and *RN* the regulator attenuation. The upper part of the figure shows the combination of these three attenuations. When the line attenuation *LN* decreases from wet to dry weather the attenuation decrease is replaced by an increase of the regulator attenuation *RN* and this increases more at the higher than at the lower frequencies corresponding to the reduction of the line attenuation.

The regulating network is mounted on an 88 mm panel as seen on the lower part of Fig. 32.

Automatic Regulation

The purpose of the regulation is, as already stated, to keep the total attenuation constant between transmitter and receiver. As an indicator of this attenuation a pilot is used, which is added on the transmitting side ahead of the transmitting amplifier. After having passed the line the pilot proceeds through the line equalizer, the regulating network and the receiving amplifier on the receiving side. After the receiving amplifier the pilot is picked up by a selective circuit and its level is measured. The value of the pilot level is a measure of the total attenuation and the immediate function of the regulation is to keep this level constant. This can be done manually by adjusting the regulating network by hand after reading the pilot level on an instrument. It can also be done automatically, and in principle an automatic attenuation regulator can either be made with moving parts, such as relays, motor-driven rotary switches or variable condensers, or also with an all-electric operation. Both methods have obvious advantages and disadvantages and both are used in teletechnics.

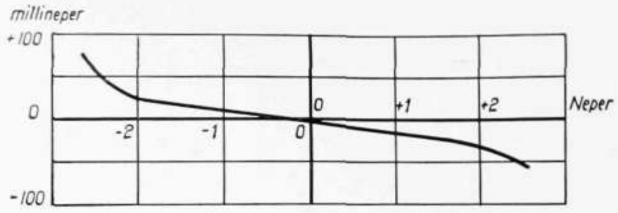
In radio technics all-electric regulation systems are used almost exclusively, while carrier telephony rather prefers to use mechanical systems. LM Ericsson has, however, for nearly fifteen years employed all-electric systems to advantage, and such a system was chosen for the new three-channel system. The principal advantages of the all-electric system are as follows:
It works inaudibly
It works quickly
It works reliably and requires no maintenance
It can be designed for narrow adjustment limits without its operation being jeopardised — e. g. by dust or vibrations.

The disadvantages of the system are mainly two:
It is rather complicated
It does not retain the last adjusted value if the pilot fails. This is a serious disadvantage only if the pilot transmitter is unreliable, which is seldom the case.

Fig. 20 shows a diagram of the whole regulating system. It has already been stated that the three channels are regulated with one common device. Consequently only one pilot is needed for each transmitting direction.

Fig. 21 X 6030

Curve of change in output level of automatic regulator as a function of change in line attenuation



On the transmitting side the regulating equipment consists only of the pilot transmitter. Its output level must of course be kept constant. The frequency must also for various reasons be kept constant. To meet these requirements in a simple way, an interesting bridge circuit has been used, which was originally introduced by Meacham. The tuned circuit *LC* and a current controlled resistance *V* form two opposite arms in a bridge, in one diagonal of which the feed-back voltage is taken out. The voltage and frequency over the other diagonal, which is connected to the anode of the oscillator valve, remains approximately constant, within certain limits, independent of fluctuations in the battery supply voltages and of the valve, as long as the amplification in the latter is maintained above a certain value.

On the receiving side the regulating equipment consists of pilot receiver, level regulator and control and indicator equipment. All this equipment is connected to the regulating network which also takes part in the automatic regulation. When regulating manually the desired attenuation value is set on attenuator β, which is adjusted in steps by a rotary switch.

When the automatic regulator is put into operation the manual attenuator is disconnected by a relay and is replaced by an attenuating circuit made up of a differential bridge with a fixed resistance *R* in one arm and a current controlled resistance *V* in the other. The entire bridge is connected into the anode circuit of a valve *C* in such a way that it is controlled by the D.C. anode current. At rest, i. e., when there is no current through the control valve, the bridge is in balance and the attenuation is very high. Through progressive increase of the anode current the attenuation of the bridge is conveniently reduced by 4 to 5 nepers.

The pilot receiver *M*, which must have a high input impedance and a great selectivity, is designed according to the superheterodyne principle. Its intermediate oscillator is stabilized in the same way as the pilot transmitter. The receiver which is negative feedback coupled and very stable, gives on the output side a comparatively high D.C. potential E_1, proportional to the

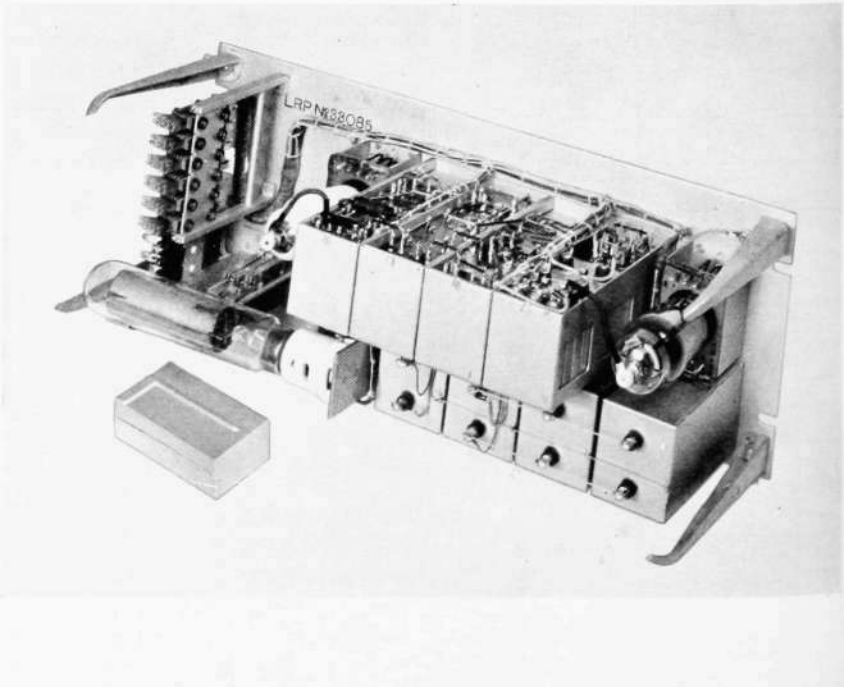


Fig. 22 X 6041

Level regulating panel

To the right, differential bridge with control valve; to the left, glow lamp for comparative voltage, shift relay and auxiliary amplifier valve; lower right, note condensers in delaying circuit

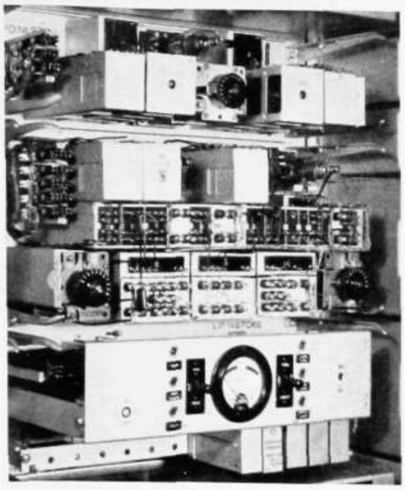


Fig. 23 X 4304

Regulating equipment

Mounted in channel bay, from the top: pilot transmitter, pilot receiver, control panel with indicating instrument and alarm relays

received pilot voltage. This D.C. potential is compared with an equally high, constant and opposing D.C. potential E_2 from a glow lamp *G*. The potential difference, which is a sensitive measure of the variation of the received pilot level, is applied to the grid of the control valve *C* of the regulating bridge in such a way, that an increasing pilot level increases the attenuation of the bridge, which consequently tends to restore the pilot level to its original value. On an instrument *I*, connected in the output circuit of the pilot receiver, the function of the regulator can be observed.

The sensitivity of the regulating system is such, that for an increase in the line attenuation of 1 neper the remaining level change is less than 0,02 neper, see Fig. 21. Such great sensitivity causes oscillations in the regulating system if a certain inertia is not introduced. Such an inertia is also desirable for other reasons, and a retarding chain, consisting of resistances *F* and condensers *K* is therefore connected in the grid circuit of the control valve, Fig. 20. By adjustments of these elements different regulating times can be obtained. To decrease further the risk of oscillation phenomena and thereby increase the speed of reaction, the regulator has a compensating device. During the course of a quick regulation a potential is obtained over the choke coil *D* in the anode circuit of the control valve. This potential is led back to the grid in opposite phase a condenser *X* and contributes to repress oscillations. Fig. 22 shows a photo of the level regulating panel and Fig. 23 the pilot transmitter, the pilot receiver and the control and indicator panel mounted on their places on the bay.

The curves in Fig. 24 show the course of the regulation during a sudden change in level. The quickest regulation is not aperiodic, but is quite satisfactorily damped.

When a line has several repeater stations connected one after the other, there is a certain risk of the regulators »hunting» each other. This manifests itself as follows: the highest change in level arising during the regulating period after each regulator in the chain is greater than the level after the regulator immediately preceding it, which means that during the regulating period a very great change in level can appear after the last regulator. Such a phenomenon can be appropriately prevented by making each regulator work more slowly than the preceding one. Despite this the regulation can, as seen from the receiving end of a circuit containing a chain of repeaters, be made to work quickly by letting the last regulator react the quickest of all. Fig. 25 shows the process with three series connected regulators arranged in this way.

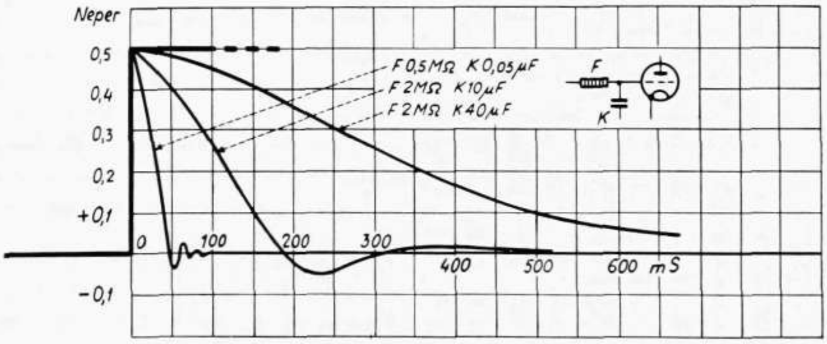


Fig. 24 X 6031

Course of regulation in a level regulator, whose input voltage is suddenly raised 0.5 neper

Curves show output voltage as a function of time in milliseconds for one regulator set for three different regulation speeds

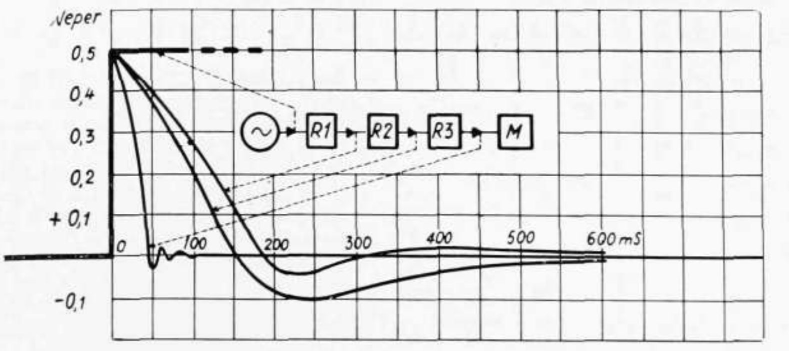


Fig. 25 X 6032

Course of regulation with three regulators R1, R2, R3 connected in series, when level ahead of the first is raised 0.5 neper

Note that over-swing of regulator R2 is not registered at M on account of the quick regulator R3

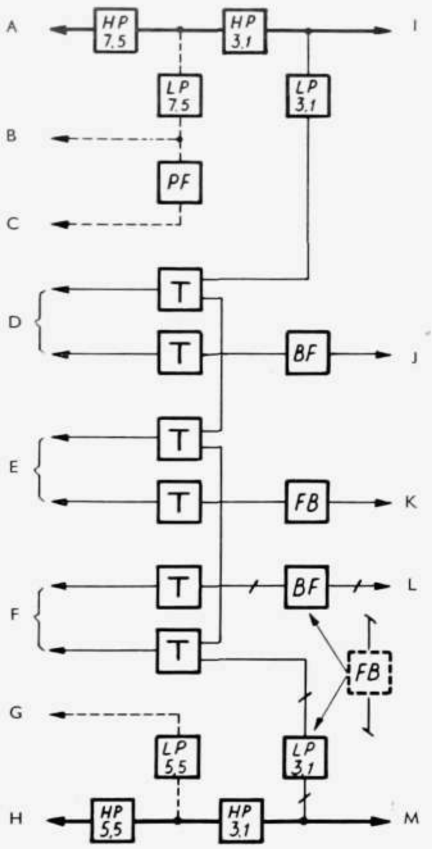


Fig. 26 X 4298

Diagram of line equipment

A	equipment of three-channel system ZM 400
B	equipment of carrier telegraph
C	program equipment
D	pair 1, to two-wire repeater or exchange
E	phantom ½, to two-wire repeater or exchange
F	pair 2, to two-wire repeater or exchange
G	equipment for carrier telegraph
H	equipment of three-channel system ZM 300
I	line 1
J	line balance 1
K	phantom balance ½
L	line balance 2
M	line 2
LP 3.1	normal low-pass filter
HP 3.1	normal high-pass filter
BF	balance filter for LP 3.1 when two-wire repeater is used
FB	phantom-balance impedance compensation and filter substitute, to be connected in line and balance when LP 3.1 is omitted in one of side circuits and phantom circuit is to be arranged
LP 5.5 HP 5.5	low-pass and high-pass filters to be used when carrier telegraph is used together with system ZM 300
LP 7.5 HP 7.5	low-pass and high-pass filters to be used when carrier telegraph is used together with system ZM 400
PF	auxiliary filter, to be used when system ZM 400 is used together with program-repeaters
T	line transformer

If the regulated level deviates from the desired value by more than ± 0.2 neper — usually caused by line faults — and this condition lasts longer than one minute, the regulator gives alarm by a relay, Fig. 20. At the same time the regulating bridge is disconnected and replaced by the manual attenuator. If the latter from the beginning is adjusted to an average value suitable for the line, the fault in level will probably not be great enough to prevent calls in process from being continued when the line is restored again. In this way one of the regulator's greatest disadvantages is evaded, as the missing pilot no longer causes a break in the circuit.

Four-wire Termination

The fork circuit with its ring signal receiver and ring signal oscillator etc. together form a separate part in the three-channel system. The differential transformer has a nominal impedance of 600 ohms in all directions, and by using 8-pole design principles it has been possible to give it a constant and phasefree input characteristic from the balancing network and the switchboard sides.

The ring signal oscillator, which supplies a 500 cycle signal current, employs two valves. The first is bridge-stabilized in the same way as the pilot transmitter, and therefore gives an input voltage stable in frequency and amplitude to the second valve, which is strongly negative feedback coupled in such a way that the output level is kept constant independent of the load. The generator gives 50 mW with a harmonic content less than 1 %. The ring signal receiver, usually called »voice-frequency ringer», is of standard design för 500 c/s. It has previously been described in the Ericsson Review No. 2/1939. The ringer works best when the signal received consists of an uninterrupted 500-cycle tone. However, some administrations work with a 20-cycle interrupted tone. The ringer can, through a simple change, also work with such an interrupted tone. In consequence of this the ring signal oscillator can be equipped with an auxiliary unit for 20-cycle interruption of the 500-cycle tone.

Line Filters

The side of the three-channel system facing the open-wire line has an impedance of 600 ohms balanced to earth, and there is no practical obstacle to connecting the transformer of the directional filter directly to the line. However, as stated in the introduction, the frequency range below 6 and 8 kc/s respectively is utilized for other circuits on the same line. The different frequency bands are therefore separated by a separation filter — as a rule low-pass and high-pass filters. The design and type of these filters vary with the equipment and the lines which are to be connected through them, but they are always present in some form or other. If the lines are connected in pairs to a phantom circuit, allowance must be made for this in the design of the line filters.[1]

One system of filters must therefore be used for each line or pair of lines in a quad connected to the carrier system. Each terminal has thus one set of line filters, and each intermediate repeater two sets. The separation filters for sub-audio telegraphy — like any equipment which uses either of the wires of the pair for telegraph circuits independent of each other with the earths as

---

[1] The possibility of using phantom circuits is intimately connected with the transposing arrangement used on the line in question. If the number of pairs exceeds a certain limit it finally becomes impossible, with a given distance between the transposition points, for each pair and each phantom circuit to find a type for transposition which up to 30 kc/s fulfills the ordinary requirements for freedom from crosstalk and resonance. One then has to choose between reducing the distance between the transposition points, which would mean that the whole profile would have to be redesigned, abandoning the phantom circuit and instead useing more pairs for working carrier systems on. As a rule the latter solution proves to be the most economical. In the Ericssons Technics No. 6/1936 M Vos and C G Aurell give under the title: »Methods for increasing crosstalk attenuation between overhead lines» a comprehensive discussion of crosstalk problems.

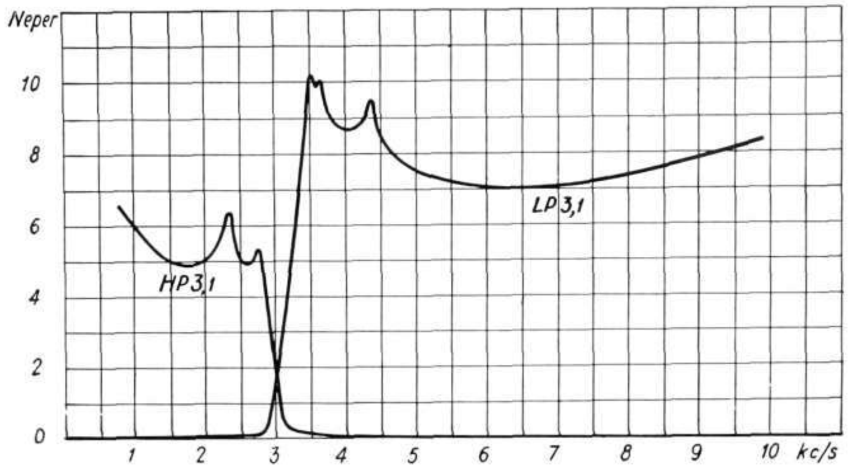


Fig. 27 X 6033
Attenuation curves for low-pass and high-pass filter LP 3.1 and HP 3.1

return (composite set) — are connected next to the line »outside» of the three-channel system and do not belong to its equipment. The arrangement of the remaining line filters in a three-channel system connected to a quad is shown in Fig. 26, which assumes that a system ZAG 11 is connected to one line-pair and a system ZAG 10 to the other pair, and that these pairs together form a phantom circuit.

The most used equipment is the low-pass filter *LP 3.1* and the high-pass-filter *HP 3.1*, which both are assembled to one unit. They separate a voice-frequency circuit below 2700 c/s. If this circuit is to be equipped with two-wire repeaters the balance filter *BF* must be added to the line balance and the filter substitute *FB* must be added to the phantom balance. When the lines also are used for carrier telegraph, filters *LP 5.5*—*HP 5.5* and *LP 7.5*—*HP 7.5* respectively, which separate a voice-frequency band below 5.5 and 7.5 kc/s respectively must be added. Finally, if one or two program circuits are arranged, filters *LP 3.1* and *HP 3.1* with the two-wire repeaters and the carrier telegraph equipment must be disconnected and a complementary program filter *PF* is connected to pair 1.

If the terminal is equipped with only one system, e. g. one system ZM 400, working on line 1, the filter set *LP 3.1* and *HP 3.1* and the balance filter *BF* in line 2 are excluded. In order to maintain the phantom circuit a filter substitute *FB* must replace *LP 3.1*, which in the phantom circuit has the same effect as the filter itself. If a two-wire repeater is used the same kind of filter-substitute must be added, replacing the balance filter.

The attenuation curves of the filters are shown in Fig. 27, 28 and 29.

Testing and Monitoring Equipment

A modern three-channel carrier system requires very little maintenance and little equipment is therefore necessary for supervision. It is limited here to an

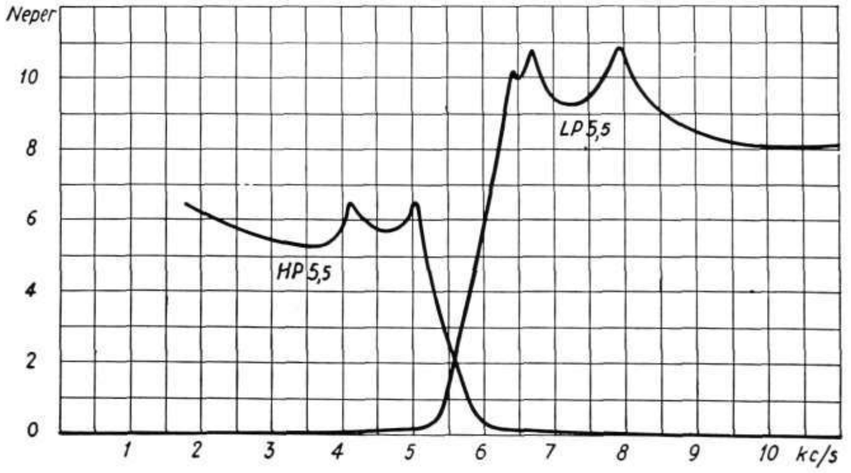


Fig. 28 X 6034
Attenuation curves for low-pass and high-pass filters LP 5.5 and HP 5.5

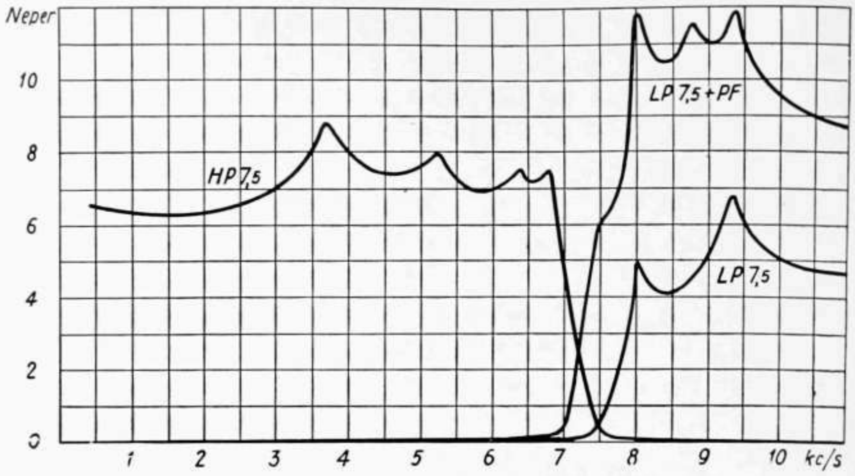


Fig. 29 X 6035
Attenuation curves for low-pass and high-pass filters LP 7.5 and HP 7.5 and total attenuation of LP 7.5 + PF

operator's set with devices for signalling, speaking and noise free monitoring, a test oscillator for the supply of 800 c/s test current and a level meter. Besides, there is a device for the synchronization of the channel oscillators. The current distribution equipment is in addition provided with milliampere meters, voltmeters and alarm devices.

The operator's set is used mostly on the two-wire side of the fork but can also be switched for use on the four-wire side, which is of importance if the circuit is to be arranged for four-wire connection. The operator's telephone set then employs two differential transformers which together form an 8-pole, Fig. 30. Two of the pole-pairs *A* and *B* are each connected in shunt to the passing circuits, and the other two pole-pairs to the telephone receiver and to the transmitter. In this way the currents from the transmitter are directed only to the pair which transmits in direction *A—B*, while the receiver receives currents only from the other pair. The person making the call is thus in connection with exchange *B* — he can ring it (with 500 c/s), speak and hear. When a ring signal is sent out the 500 c/s oscillator takes the place of the transmitter. If the leads *K—K* are shifted on one side of the microphone transformer, the direction is reversed, so that the caller will now only come into connection with *A*. If he wants to speak with both *A* and *B* at the same time, he breaks one of the microphone transformer leads *K—K*, which causes the 8-pole to be unbalanced and the directional effect to cease. The balance in the fork *T* is maintained all the time, so that no currents pass from one branch to the other of the four-wire circuit this preventing echo and singing. When using the monitoring equipment in two-wire connection the differential transformers are disconnected.

The test oscillator is designed in exactly the same way as the ring signal oscillator which has just been described. It has, unloaded, a terminal voltage of 1.55 volts and an internal resistance of 600 ohms and thus supplies 1 mW to a line with a 600 ohms real impedance.

Fig. 30 X 6036
Diagram of monitoring panel in four-wire arrangement

Microphone and ringsignal oscillator are connected alternatively

A	connection with side A
B	connection with side B
A—B	repeater in direction A → B
B—A	repeater in direction B → A
M	transmitter
O	receiver
K	switching point
T	differential transformers

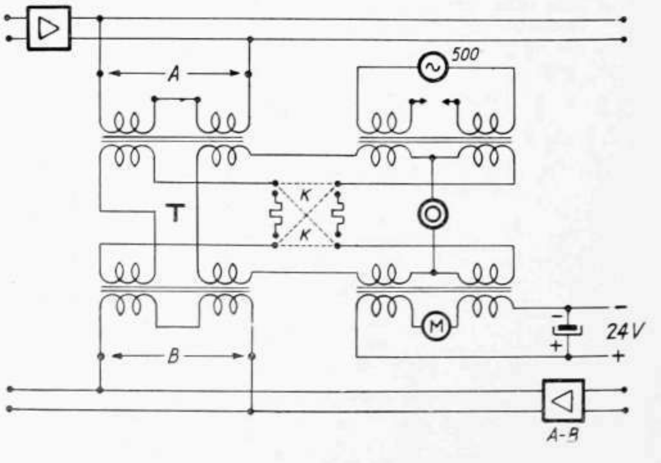
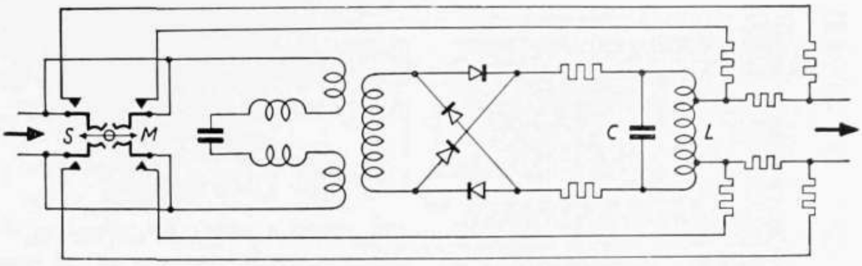


Fig. 31 X 6037

Diagram of synchronizing apparatus

Tuned circuit L-C is tuned for 1600 c/s; when transmitting, with key in position S, 800 c/s enters apparatus and equal voltages of 800 c/s and 1600 c/s leave; when receiving, with key in position M, 800 ± △ c/s and 1600 ± △ c/s enter, while 1600 ± △ and 1600 ± 2 △ leave; △ is error of synchronism in c/s



The level measuring set, which measures voltages and levels between — 3.2 and + 2.6 nepers with frequencies between 200 and 100000 c/s, has previously been described in the Ericsson Review No. 2/1939.

The synchronization of the channel oscillators is based on a new principle. Let it be supposed that a transmitter with the carrier frequency b is simultaneously modulated with the frequencies t and $2t$. If the modulator transmits, for example, the higher side band the frequencies $b + t$ and $b + 2t$ are present on the line. Let it further be supposed that the receiver oscillator, which also ought to have the frequency b, has increased so that in reality it has the frequency $(b + \triangle)$. The demodulated frequencies will then be:

$$f_1 = b + t - (b + \triangle) = t - \triangle$$
$$f_2 = b + 2t - (b + \triangle) = 2t - \triangle$$

If a non-linear resistance, e. g., a copper oxide rectifier, is inserted on the receiver side, second harmonics of both frequencies, namely $2f_1$ and $2f_2$, are produced there. Only $2f_1$ and the f_2 present of interest. If this mixture of frequencies is listened to with a telephone receiver which itself is non-linear, a beat tone s between the two last mentioned frequencies will be heard.

$$s = f_2 - 2f_1 = (2t - \triangle) - (2t - 2\triangle) = \triangle$$

The difference between the two carrier frequencies is thus heard.

The frequency t on the transmitting side is taken from the test oscillator. In a simple circuit, Fig. 31, $2t = 1600$ c/s is produced, which is then mixed with $t = 800$ c/s and supplied to the channel which is to be synchronized. The same device serves on the receiver side for the doubling of $f_1 = t - \triangle$ and for the suppression of the undesired tones. The beat thereby becomes the clearest possible and the synchronization will be very easy to execute even for a person with an untrained ear. As the level measuring set contains a rectifier next to the instrument it can also be used for indicating the beat as long

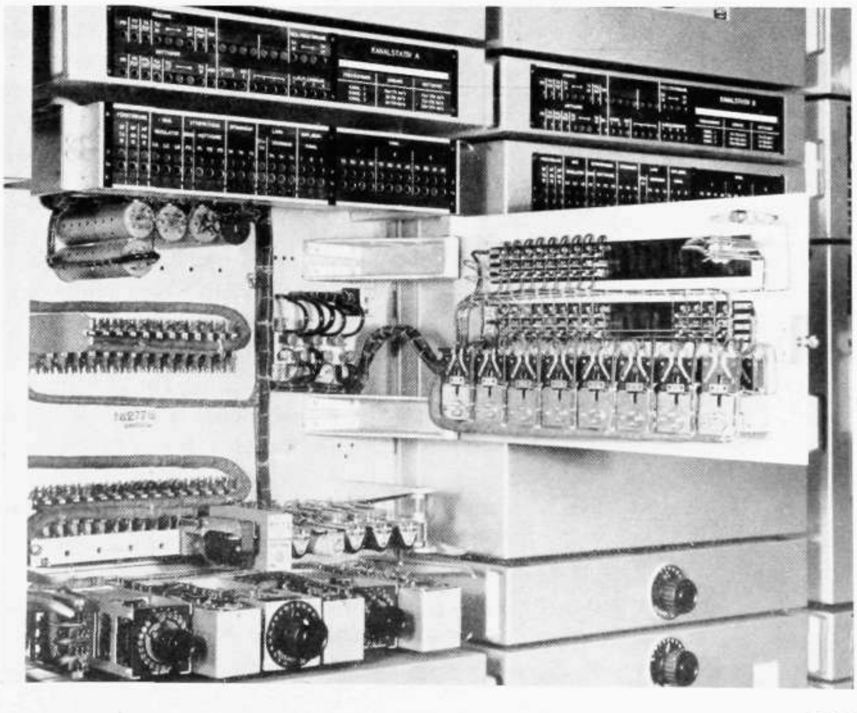


Fig. 32 X 6042

Jack field and current distribution panel, latter with opened front

On front plate, switches; on back plate lower part, relays; *below, current distribution panel,* regulating panel with potentiometers for line slope, receiver level and auxiliary line attenuator as this is not higher than 10 c/s. The level measuring set then takes the place of the telephone receiver and the beat is indicated by the pointer deflections. With suitable setting the deflections can be made to cover the greater part of the scale.

Current Distribution

The required power for operating the system is taken in on the main fuse panel on one of the bays and is from there distributed to the current distribution panels, of which there is one for each bay. On these panels the fuses, power switches, reduction resistances, meter shunts, alarm relays, alarm lamps and in one of the bays an alarm bell are placed. These panels are arranged with double plates, of which the front plate can be swung out to make all parts easily accessible, Fig. 32. The relays are mounted on bars, which also can be swung out.

Bay Assembly

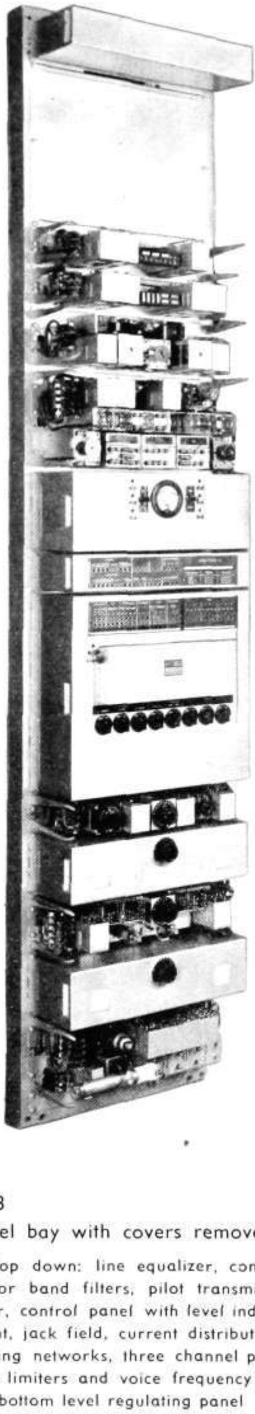


Fig. 33 X 4300

Channel bay with covers removed

From top down: line equalizer, compensating filter for band filters, pilot transmitter, pilot receiver, control panel with level indicating instrument, jack field, current distribution panel, regulating networks, three channel panels with volume limiters and voice frequency amplifiers and at bottom level regulating panel

The terminal channel and amplifying equipment, including the automatic regulator, together with the current distribution panel, fill the front and rear of an entire bay 485 mm wide and 2590 mm high, Fig. 33. A second bay takes the line filters, forks and ringers as well as the current distribution panel for two three-channel systems, one ZAG 10 and one ZAG 11. All equipment for monitoring and testing is placed on this bay, Fig. 34, as well as a jack field, in which all circuits, both the carrier and the physical concerning the system, are accessible. All the auxiliary circuits necessary for supervision or belonging to the test equipment are connected to the jack field. The bay is furthermore equipped with spare panels for ringer, ring signal oscillator and line filters, and these are also connected to the jack field. At the top of the bay there is the main fuse panel from which the incoming power is distributed. The space on the line filter bay is relatively large, but this is necessary, as local conditions often require extra line filters to be added.

A terminal consisting of two three-channel systems with their line filters and ringers thus takes three bays, Fig. 35. The bays are electrically joined with easily fixed plug-in type interconnection cables. The intermediate repeater takes one bay, and the necessary line filters require, as on the terminal, one bay for two repeaters. The test equipment is here limited to an operator's set and a level measuring set. Fig. 36 shows the complete equipment with two repeater bays. On each of them may be seen the switching keys and indicator instruments of the regulators. At the top of the middle bay a fuse panel is placed as on the terminal. The line transformers do not form part of the three-channel system equipment but, as Fig. 26 shows, they are, as regards their connection, close to the line filters. For this reason a place has been provided for them on the rear of the filter bay both in the repeater and in the terminal. The wiring is arranged in such a way, however, that they can also be placed outside of the bay in the event of transformer racks being available.

In stations along the line where the circuits need to be available for low frequency operation, the high frequency band is by-passed in a high frequency shunt which contains two standard low-pass—high-pass filter sets. To prevent crosstalk between the phantom circuits on each side of the shunt, the high-pass filters are joined through a transformer with a static-earthed screen between the windings, Fig. 1. The two filter sets and a jack panel, which also contains the above mentioned transformer, are mounted on an iron frame 485 × 878 mm which is intended for wall mounting. Thus for one quad two such filter units are needed. A third iron frame of the same size is provided for taking the balance filters which are needed if two-wire repeaters are to be connected into the physical circuits. In the same balance unit there is space for all necessary line transformers and filter substitutes and balance filters which may be required for the equipment of the whole quad. A complete high-frequency shunt for a quad thus consists of three units together requiring 1455 × 878 mm. The shunt can also be mounted on a standard frame.

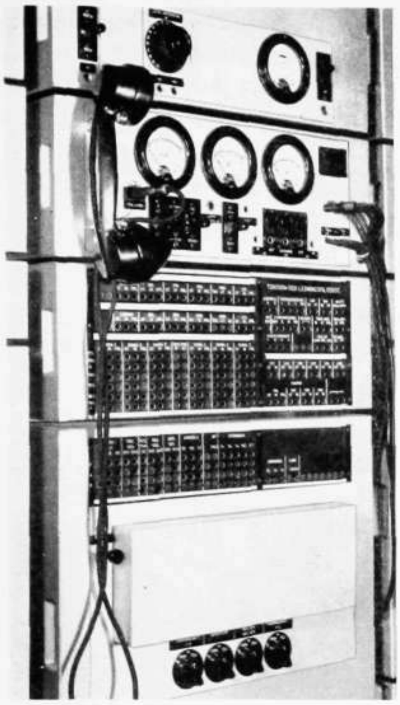


Fig. 34 X 4301

Control and test equipment of terminal

From top down: level measuring set, meter and monitoring panel, jack field and current distribution panel

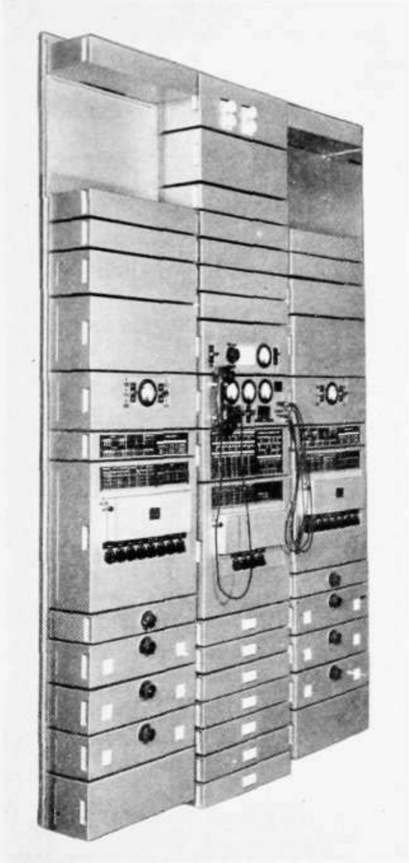


Fig. 35 X 4302

Complete terminal for two three channel systems

In centre: line filter and ringer bay; on sides: channel bays

Current Consumption

Four sources of power are needed for the system:

anode current	130 volts ± 5 %
filament (heater) current	24 » ± 5 %
relay current	24 » ± 15 %
ringing current	80 » 20 ~

The filament circuits can be connected for either 21 or 24 volts supply and the power can either be D.C. or A.C. In the latter case 21 volts is suitable. The average value of the filament voltage should, in consideration for the life of the valves, not deviate by more than ± 3 % from the nominal value, whether this is 21 or 24 volts.

The current consumption for normal operation and the maximum current consumption with all test equipment and spare equipment switched on and all alarm circuits in function are seen in table II.

Table II. Current consumption of three-channel system

equipment	anode current at 130 V		filament current at 24 V		relay current at 24 V	
	normal	maximum	normal	maximum	normal	maximum
	A		A		A	
terminal, 1 system	0.25	0.35	4.2	5.5	0.31	0.90
terminal, 2 systems	0.47	0.65	7.9	9.8	0.60	1.60
repeater, 1 system	0.25	0.31	3.3	4.3	0.21	0.72
repeaters, 2 systems	0.50	0.62	6.6	8.2	0.42	1.40

The source of power for relay current and filament current can be the same, e. g. one battery can supply both of them, but separate feeders should be used in such a case right from the battery terminals.

A pole changer is sufficient for the generation of the ringing current. It can be connected so that it is normally at rest and is started from the system only when ringing current is needed.

Types of Valves

Three different types of valves are used in the system, a small one, RTR 4141, and two larger ones RTR 4341 and RTR 4342. The most important data pertaining to them are as follows:

	RTR 4141	*RTR 4341*	*RTR 4342*
filament (heater) voltage	5.25 V	21 V	21 V
filament (heater) current	0.380 A	0.285 A	0.315
anode voltage	130 V	130 V	130 V
anode current	6 mA	10 mA	40 mA
grid bias	— 5 V	— 1.5 V	— 8.5 V
mutual conductance	1.2 mA/V	8 mA/V	9 mA/V
internal resistance	200000 ohms	250000 ohms	15000 ohms

Four valves RTR 4141 work in series on 21 volts.

A glow lamp of about 80 volts glow voltage is used in the automatic level regulator.

Measurements

A typical curve of overall quality of a channel from fork to fork is reproduced in Fig. 37, while Fig. 38 shows the limits within which twenty arbitrarily selected curves all lie. The variations of the propagation time within the transferred band is seen from Fig. 39, which has been plotted from impedance measurements from the two-wire side of a fork, to which the transmitted band has been returned. During these measurements, when both terminals must be close to each other, the modulator oscillator was kept in true synchronism with the demodulator oscillator by special arrangements.

The near-end and far-end crosstalk figures are given in table III.

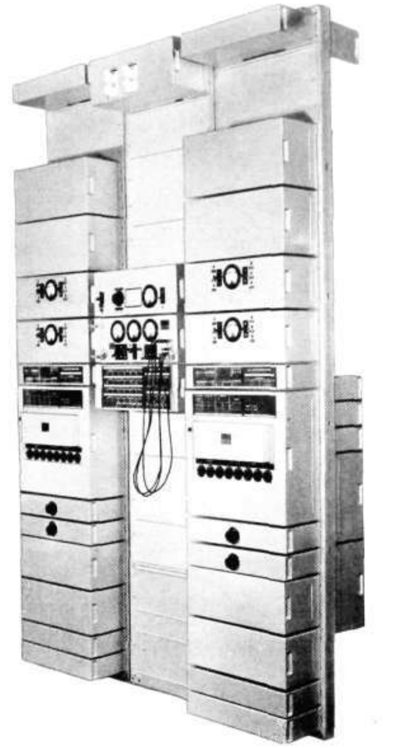


Fig. 36 X 4303

Intermediate repeater for two systems

In centre: line filter bay with control and test equipment; at sides: repeater bays each with two level indicating instruments

Table III. Measured near-end and far-end crosstalk attenuations of the terminal

Attenuation values in neper between points with equal nominal level
S transmitting channel M receiving channel

Average value measured at terminal						Lowest value measured at terminal					
A channel			B channel			A channel			B channel		
1	2	3	1	2	3	1	2	3	1	2	3
S	9	10	M	8.5	8.8	S	9	9	M	8.2	8.4
>10	S	>10	8.3	M	8.6	10	S	>10	8.2	M	8.2
>10	>10	S	8.6	8.9	M	>10	10	S	8.6	8.8	M
M	8.5	8.7	S	9.5	10	M	8.2	8.5	S	8.5	9.5
8.5	M	9.1	>10	S	>10	8.2	M	8.8	>10	S	>10
8.3	8.5	M	>10	10	S	8.2	8.2	M	>10	9.5	S

It is to be noted, that the measured crosstalk to the greatest part is unintelligible and according to C.C.I.F. rightly ought to be considered and measured as noise. When there are only three channels the rythm of speech will come through although unintelligible, and at high crosstalk attenuations, when in any case only the rythm of speech is heard and the words are not expected to be understood, the noise effect is the same as if the noise had been of *intelligible nature. It can therefore be justified in this case to measure the* interference as crosstalk and not as noise.

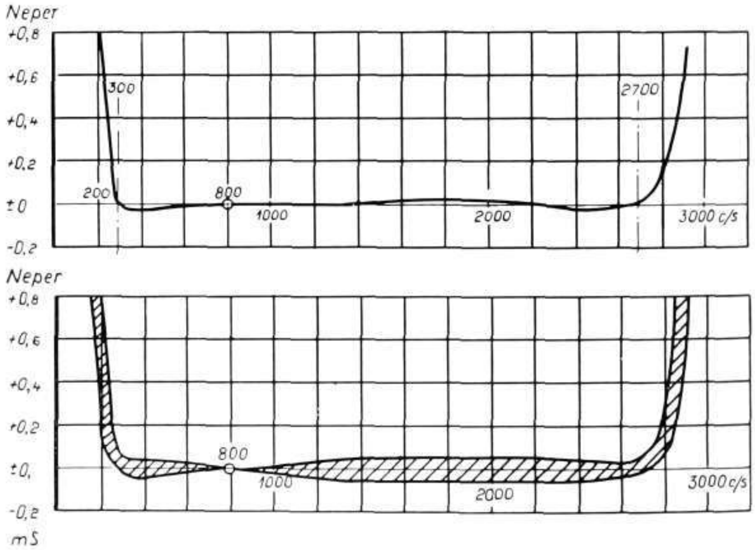


Fig. 37 X 6038

Over-all attenuation curve from fork to fork

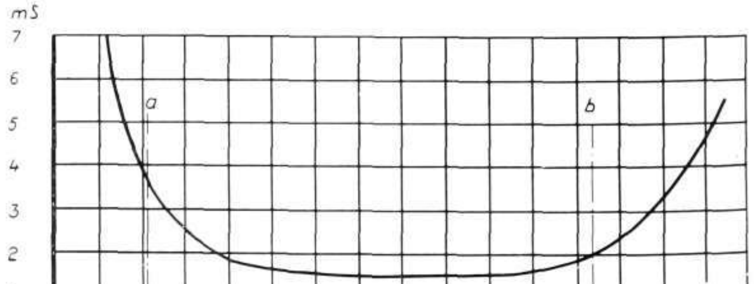


Fig. 38 X 6039

Limits within which all of a great number of arbitrarily selected over-all attenuation curves fall

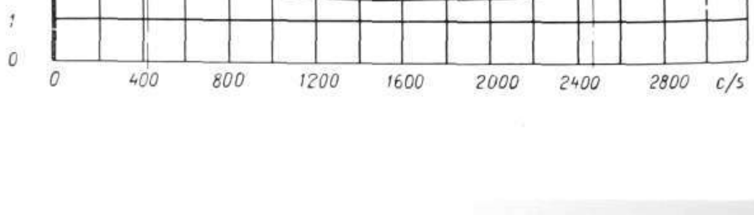


Fig. 39 X 6040

Propagation time from fork to fork

Lines a and b show the position of highest and lowest frequency of an 18-channel voice frequency telegraph system

Rural Line Repeater with Negative Feed-back

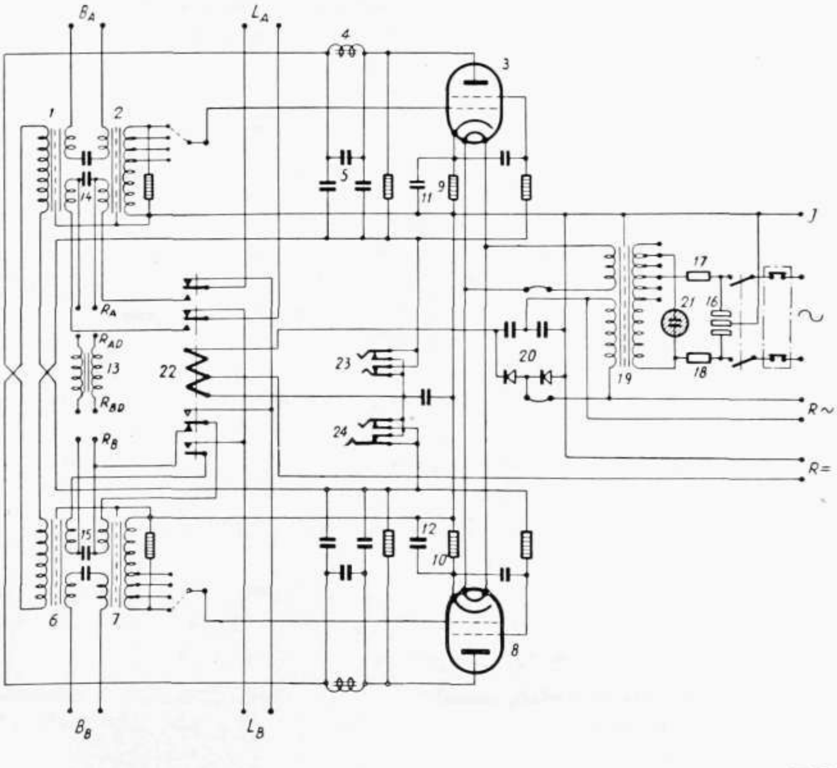
J LJUNGBERG, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

U.D.C. 621.395.64

For lines, which are long but not long enough or with so many circuits that a normal repeater station, is warranted a small repeater equipment is often useful to compensate part of the line attenuation. This equipment consists of 2-wire repeaters, which may be connected to the electric mains and which are easy to install and to maintain.

The rural line repeater ZMK 5001, described below, is designed to meet the above demand and is an improvement on LM Ericsson's rural line repeater of older construction. The line repeater has smaller dimensions in its present construction.

The principal diagram for the rural line repeater is shown in Fig. 1. The circuit from the subscriber *A* is connected to L_A and the circuit from the subscriber *B* to L_B. The balancing networks corresponding to the circuits mentioned are connected to B_A and B_B respectively. The speech currents from the subscriber *A* enters the differential transformer, which consists of the transformers *1* and *2*, and is passed on through the grid winding on tranformer *2* to the repeater valve *3*, which amplifies the current in direction *A* to *B*. The grid winding is equipped with 4 tappings, by means of which the gain may be varied. Behind the amplifier valve there is a filter which limits the amplified frequency range to 2500 c/s. This filter consists of the coil *4* and the three condensers *5*. After having passed the filter the currents flow through the anode winding on the transformer *6* to the other differential transformer of the repeater and is put out on the circuit L_B to the subscriber *B*. The speech currents in the opposite directions pass the transformer *7*, the amplifier valve *8* to the transformer *1* in a similar way.



X 5887

Fig. 1
Diagram of rural line repeater

1, 2	differential transformer
3	repeater valve
4	filter coil
5	filter condensers
6, 7	differential transformer
8	amplifier valve
9, 10	resistance
11, 12	condensers
13	filter coil
14, 15	filter condensers
16	lightning protector
17, 18	fuses
19	mains transformer
20	rectifier
21	glow lamp
22	relay
23, 24	jacks

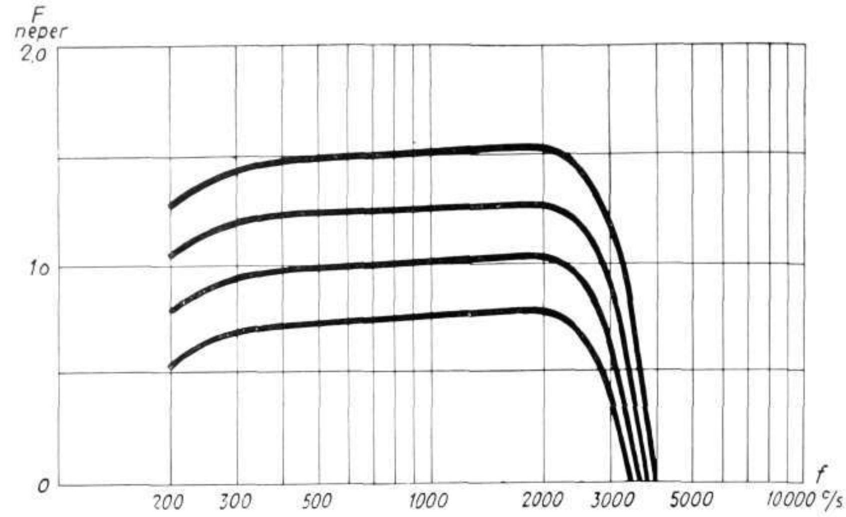


Fig. 2 X 5888
The gain F as a function of requency f

The feedback is obtained by the resistances *9* and *10* not being parallel with a condenser of sufficient size to make a short-circuit for A.C. By means of the feedback the gain is kept more constant with varying mains voltage and the disturbances from the anode and filament voltages are better suppressed. Further the repeater will be more independent of the ageing of the repeater valves. The condensers *11* and *12* serve as equalizers, by means of which a small rise in the frequency is obtained in the gain curve.

The gain curve of the repeater is shown in Fig. 2. The maximum gain at 800 c/s is 1.5 neper. By means of the tappings on the transformers *2* and *7* the gain may be reduced in 3 steps of 0.25 neper each. The gain corresponding to the different steps is shown on Fig. 2.

Ringing current is used of 15—50 c/s A.C. and the repeater is equipped with a corresponding shunt, which may, however, be disconnected if a normal ringing repeater is desired. The coil 13, connected with its terminals R_{AD} to R_A and R_{BD} to R_B, forms together with the condensers *14* and *15* a low-pass filter. The attenuation for the ringing current with the ringing shunt in function is shown on Fig. 3. If the line is so long that the ringing current has to be reduced at the repeater point, a ringing repeater of normal design has to be connected between R_A and R_B.

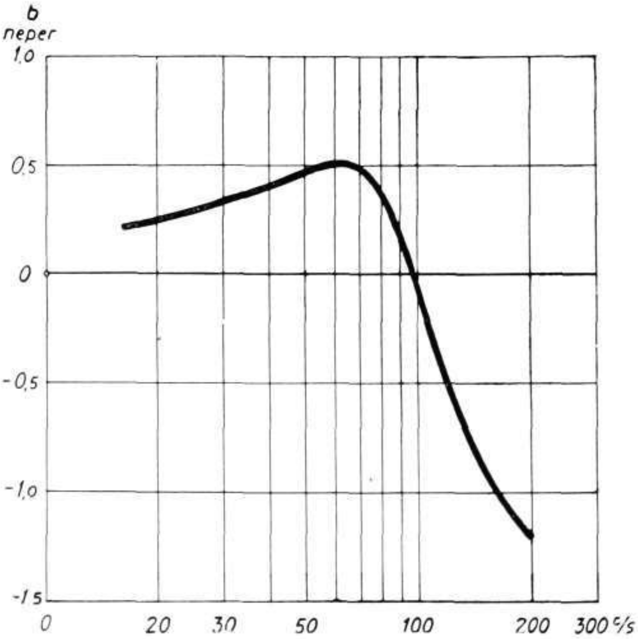


Fig. 3 X 5869
The attenuation *b* for the ringing current as a function of frequency f

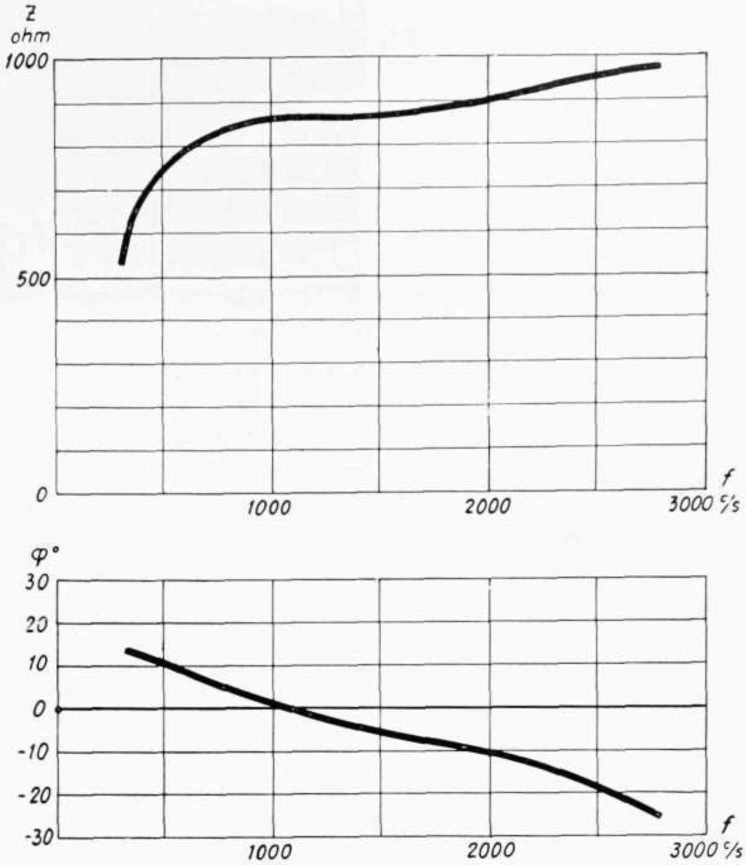


Fig. 4 X 5890
The impedance Z and its phase angle φ as a function of frequency

The input impedance for the repeater is shown on Fig. 4.

The repeater may be connected to electric mains with A.C. voltages 110, 127, 140, 150, 220 or 245 V and with a frequency between 25 and 60 c/s. Voltage adjustment is done by means of a switch on the mains transformer *19*, Fig. 1. On the mains side the repeater is provided with a lightning protector *16* and with the fuses *17* and *18*. Close to the mains contact there is, besides the normal disconnecting switch, also an interruptor which automatically disconnects the mains voltage when the cover is removed from the repeater. By this arrangement every part of the repeater is voltage-free as soon as the cover is removed. Across the mains transformer there is a glow lamp *21*, which indicates when mains voltage is on.

The mains transformer *19*, Fig. 1, delivers both 6.3 V A.C. to the filaments of the valves and 100 V which gives an anode voltage of approximately 160 V by means of a metal-rectifier *20* used as voltage-doubler. I a ringing repeater is used together with the repeater, A.C. voltage may be obtained for the outgoing signal from the terminals *R* ∼ while D.C. for the relays from *R* =, and the right valve, 24 V, is obtained by a tapping on relay *22*.

After the rectifier *20* the anode current passes through relay *22*, which partly acts as filter coil for the anode current and partly as reconnecting relay. If *e. g.* the A.C. voltage from the electric mains fails, relay *22* falls and connects the subscriber *A* directly with the subscriber *B* so that the connection may be ensured though without amplification until the mains voltage comes back.

The valves used are indirectly heated, screened pentodes of the types RTR 4141, KTZ 63 or 6J7G. The filament voltage is 5.25 V for RTR 4141 and 6.3 V for KTZ 63 and 6J7G. The filament current is 0.37 A and 0.3 A respectively. The total power consumption from the electric mains is approximately 10 W.

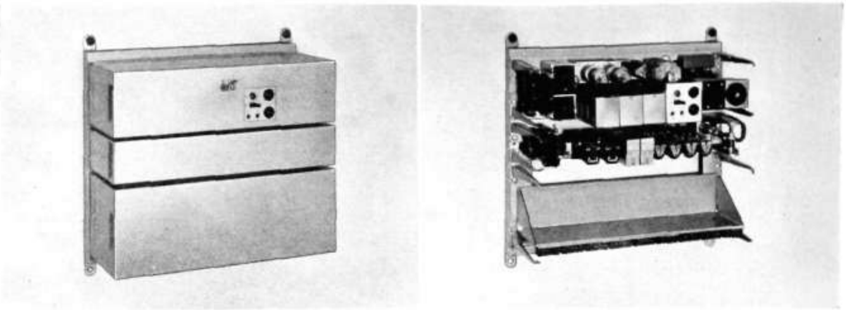


Fig. 5 X 5889

Repeater equipment ZDA 1003 comprising

rural line repeater ZMK 1003 mounted together with a ringing repeater and a transformer shelf; to the left with, to the right without, covers

The repeater is mounted on a 3 mm iron panel with the dimensions 482.6×132 mm. A removable cover with a depth of 180 mm is placed over all those parts, which need not be accessible during a normal function. The mechanical design is seen from Fig. 5, showing the repeater (the upper panel on the figure) partly with and partly without covers. In an aperture in the cover are to be found the switch, the glow lamp, the fuses and the jacks *23* and *24*, Fig. 1, intended for the measurement of the anode current.

Fig. 5 shows the repeater mounted on an iron frame together with a ringing repeater ZMN 1001 and a shelf for nine line transformers and balancing networks. The repeater can be delivered either without this iron frame or with an iron frame for other combination possibilities according to the table below, Fig. 6. When the repeater is delivered mounted on a frame together with a transformer shelf and a ringing repeater, the required connections between these are executed so that one only has to connect the mains voltage, the lines *A* and *B*, and to place the necessary transformers and balancing networks on the transformer shelf.

type	height of frame mm	number		
		rural line repeater ZMK 5001	ringing repeater ZMN 1001	transformer shelves
ZDA 1001	165	1	—	—
ZDA 1002	345	1	—	1
ZDA 1003	435	1	1	1
ZDA 1004	300	2	—	—
ZDA 1005	655	2	—	2
ZDA 1006	835	2	1	2
ZDA 1007	835	2	2	2
ZDA 1008	435	3	—	—
ZDA 1009	520	3	—	2
ZDA 1010	1055	3	1	2
ZDA 1011	1055	3	2	2
ZDA 1012	1055	3	3	2

Fig. 6

Combination possibilities for rural line repeater ZMK 5001 together with ringing repeater and transformer shelves

New Ringing Repeater

J LJUNGBERG, TELEFONAKTIEBOLAGET L M ERICSSON, STOCHOLM

U.D.C. 621.395.64

With the ringing repeater types earlier used for two- and four-wire circuits with 15—50 c/s signalling current, the outgoing signal from the ringing repeaters is shorter than the incoming and furthermore the signal is delayed a comparatively long time owing to the inertia of attraction which is necessary in repeaters of older design. This has caused the inconvenience that, as regards long lines needing several ringing repeaters one after the other, the length of the ringing signal is reduced in each ***ringing repeater. Thus the original signal must have a length exceeding the total of*** **these reductions.**

Below a ringing repeater is described, where the output signal has the same length as the incoming one and where the operation time has been reduced to less than a third of that for ringing repeaters of older type.

The diagram of the new ringing repeater is shown in Fig. 1. The ringing repeater is connected both to a D.C. voltage applied in order to feed the relays and to an A.C. voltage for the outgoing ringing signal. For the signalling from subscriber *A* to subscriber *B* the relays *1*, *3* and *5* are used while the relays *2*, *4* and *6* are for signalling in opposite direction.

The ringing repeater works as follows:

If a signal enters R_A the relay *1* is actuated and transmits over its contacts *1* and *2* minus voltage to relay *3*. This relay is actuated and separates F_B and L_B by means of the contacts *1*, *2*, *4* and *5* and transmits a new ringing current to L_B over the contacts *1*, *3*, *4* and *6*. Over the contacts *7* and *8* on the same relay minus voltage is passed to relay *5*, which is actuated and by means of the contacts *1* and *2* disconnects relay *2* which acts as receiving relay for the opposite signalling direction. The break-off of the relay *2* is done in order to prevent the reflected part of the signal, returning from L_B when relay *3* is disconnected, from entering relay *2*, which otherwise would transmit a false signal in opposite direction. Relay 5 is slow-acting on break so

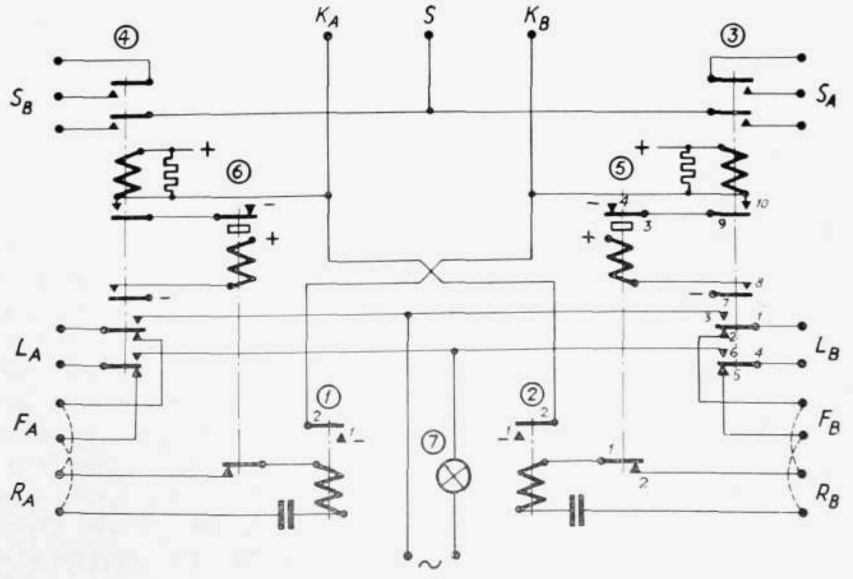


Fig. 1 X 5873

Diagram of new ringing repeater

F_A, F_B	to repeater
K_A, K_B	for station signalling
L_A, L_B	to line
R_A, R_B	to ring signal relay
S, S_A, S_B	for clearing
1, B, 5	relay for signal from A-subscriber to B-subscriber
2, 4, 6	relay for signal from B-subscriber to A-subscriber
	lamp for limiting outgoing signal currents

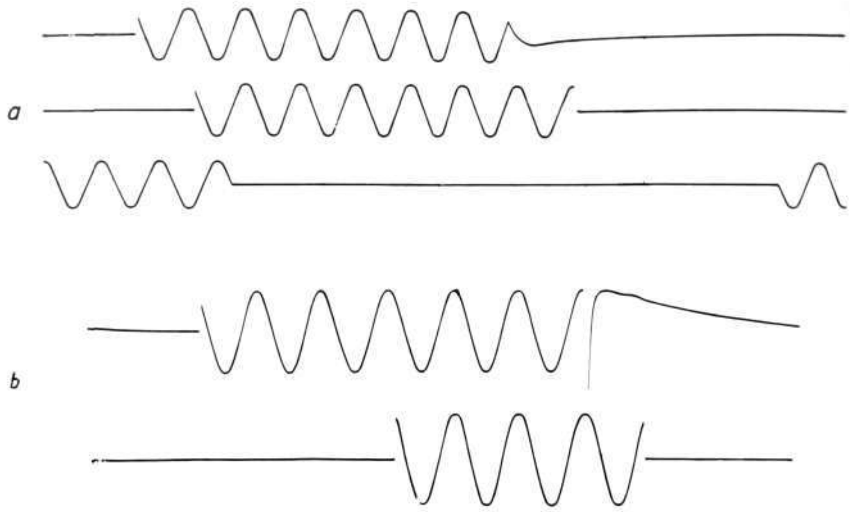


Fig. 2
Oscillogram

X 5874

- a for the new ringing repeater
- b for an older ringing repeater

that the signalling direction L_B to L_A is blocked long enough to enable the reflected wave to be extinguished before relay *5* breaks off and once more connects the receiving relay *2*.

If relay *1* gets a very short signal so that its contacts are connected for an instant only, relay *3* would connect and disconnect without relay *5* being actuated. In such a case relay *3* would transmit a short signal over L_B causing a reflected wave, which would then freely pass on to the receiving relay *2*, which is sending out a signal on L_A over relay *4*. In that way the signal would oscillate through the ringing repeater. This is prevented by the contacts *9* and *10* on relay *3* and by the contacts *3* and *4* on relay *5*. Over these contacts relay *5* is forced to act as soon as relay *3* has closed its contacts *9* and *10*, relay *3* being incapable of disconnecting until relay *5* has been actuated and has broken its contacts *3* and *4*. For signalling in the opposite direction the relays *2*, *4* and *6* are used in the way described above for the relays *1*, *3* and *5*.

The terminals S, S_A and S_B serve to forward the clearing signal etc. to the operator when the repeater is used combined with a cord-circuit repeater. The terminals K_A and K_B may be used for controlling the ringing repeater *e. g.* from the supervisory device of the repeater station. The lamp *7* serves only to limit the outgoing ringing current on short lines or if a short-circuit occurs on the line.

Fig. 2 shows oscillograms for a new and an old ringing repeater. The upper curve of the first oscillogram shows the time during which an A.C. voltage with a frequency of 25 c/s has been connected to R_A, Fig. 1, the central curve shows the time during which the signal has been transmitted on to L_B and finally the third curve shows the time during which the receiving relay *2* has been disconnected by means of the contacts *1* and *2* on relay *5*. The time from the signal entering R_A and until the new ringing current reaches L_B is approximately 40 ms and the time from the voltage disappearing on R_A until the outgoing signal stops is 43 ms. The receiving relay *2* is disconnected about 150 ms after the outgoing signal stops. The upper curve of the other oscillogram shows the incoming voltage on a pair of terminals corresponding to R_A, Fig. 1, and the lower curve the outgoing voltage from the ringing repeater on a pair of terminals corresponding to L_B for a ringing repeater of an older design. This ringing repeater does not disconnect the receiving relay for the opposite signalling direction. The protection against the reflected ringing voltage is obtained by the considerable time required to start a signal from the ringing repeater. The time from the signal entering the ringing repeater and until the new signal starts is 140 ms, and the time between the end of the incoming signal has stopped and the outgoing signal stopping is 45 ms.

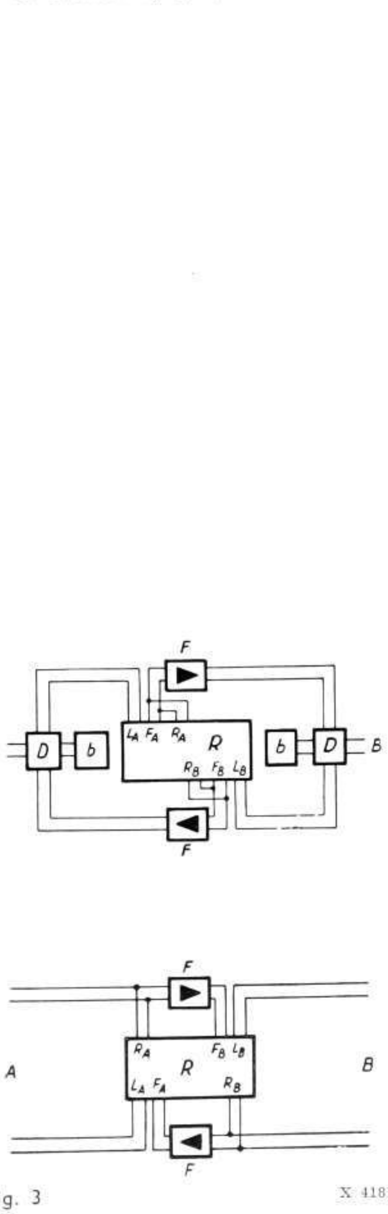


Fig. 3

X 4181

Connection of the ringing repeater together with two-wire repeater and a four-wire repeater

A, B	line to A- and B-subscriber
R	ringing repeater
F	repeater
D	differential transformer
b	balance

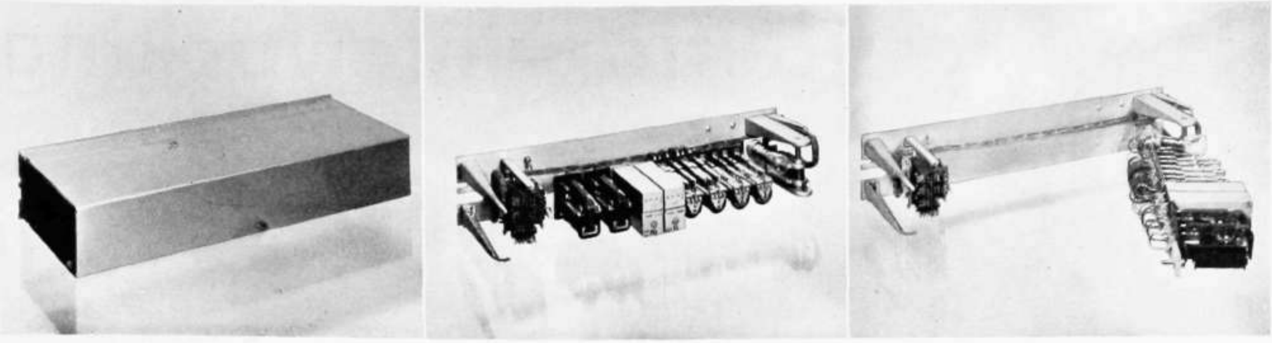


Fig. 4 X 7284

Ringing repeater

to the left with cover, in centre without cover, to the right with the bar swung out

A comparison between the two oscillograms shows that the new ringing repeater delays the signal only 40 ms and transmits a new signal of practically the same length as the incoming one (in the oscillogram corresponding to an extension of the signal by 3 ms) and blocks the reversed signalling direction for false signals during a period of 150 ms. As to the ringing repeater of older design the corresponding periods are: a signal delay of 140 ms, a shortening of the signal by 95 ms and a protection time for false signals in the opposite direction of 140 ms.

If several ringing repeaters are connected one after the other in a circuit it is at once seen that, with the ringing repeater of the older type, one has to give a very long signal in order to compensate for the reduction of the signal in each ringing repeater. Thus it is practically impossible, when calling to determine the length of the signal at the far end of the line. With the new ringing repeater, however, the length of the transmitted signal needs not to be greater than the length of signal to be received at the far end of the line. The signalling may, therefore, also be of code type. Furthermore, a considerable decrease in time for the transmission of the signal is obtained.

On the upper part of Fig. 3 is shown how the ringing repeater is to be connected to a two-wire repeater and on the lower part how to connect it to a four-wire repeater. The connection is done in the same way as for ringing repeaters of older types, thus enabling replacement without difficulty of older ringing repeaters.

The mechanical design of the ringing repeater is seen on Fig. 4. The repeater is mounted on an iron panel with the dimensions 482.6 × 88 × 3 mm, provided with a removable cover of a depth of 180 mm. On the panel, counting from the left, the soldering tag, the receiving relays with their series condensers, the relays for the outgoing signal, the slow-acting break relays and the lamp for the limiting of the outgoing ringing current. All the relays are mounted on a movable bar in order to facilitate the inspection of the soldering etc. on the wiring side of the relays.

The ringing repeater is designed for 24 V D.C. and for transmission of signals with a signal frequency between 15 and 50 c/s.

New Press-Button Interlocking Control Machine

H INSULANDER, L M ERICSSONS SIGNALAKTIEBOLAG, STOCKHOLM

U.D.C. 656.257

In conjunction with the ordering by the Swedish State Railways of twenty-five press-button interlocking control machines, Signalbolaget put in hand a re-designing of the press-button interlocking control machines as formerly manufactured. The construction of press-button interlocking control machine thus arrived at, which displays a number of essential improvements in respect of facility for alterations and enlargements, is described in the following article.

The press-button interlocking control machines supplied by LM Ericsson's Signalaktiebolag in the course of years have without exception been made in single examples. There had been no manufacture of several apparatus at a time. The apparatus therefore have been individual to a rather high degree. A typical apparatus from this period of manufacture is shown by Fig. 1. Briefly, the apparatus consists of a sheet-metal box on the front of which a number of operating and indicating devices are fitted in prescribed order.

It often happens, however, that a station is enlarged or altered. In that event the interlocking plant must also be altered and adapted to the new lay-out of the station. The old mechanical interlocking machines were fairly easy to alter by putting in fresh cranks and levers in reserve positions or by replacing cranks and levers by fresh ones having different functions. The procedure was similar with the older electrical interlocking machines, where new switches could be fitted in reserve positions or put in place of old ones. This build-up of the apparatus by means of a number of more or less standardized components — cranks, levers or switches — fitted into a frame, not only facilitated alteration and extension, but simplified manufacture to a high degree, while it also made it possible to keep stocks of parts for manufacture.

The situation was quite different with the press-button interlocking machine. Of course, certain stocks of parts for the operating devices could be held, but any alteration or extension of an apparatus was a rather troublesome procedure, as fresh holes had to be bored in the front plate and so on. Nor was any stock of semi-finished apparatus possible as the finished apparatus was

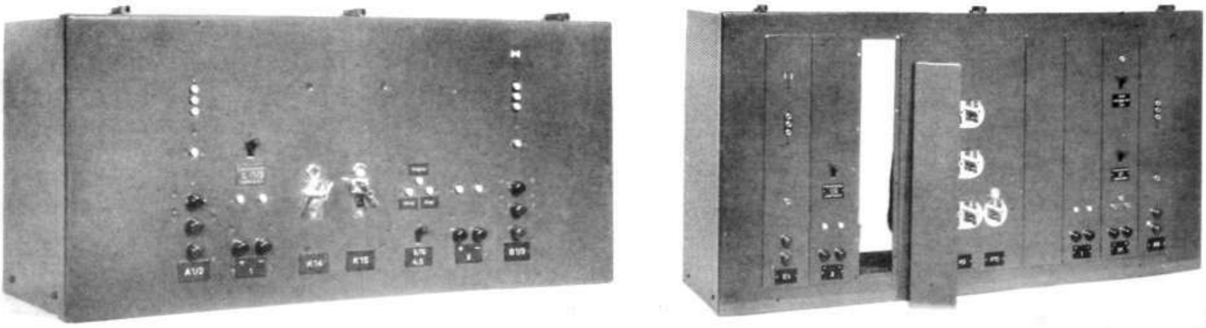


Fig. 1 & 2 X 7274

Press-button interlocking machines

left, as formerly constructed, right, in the new design

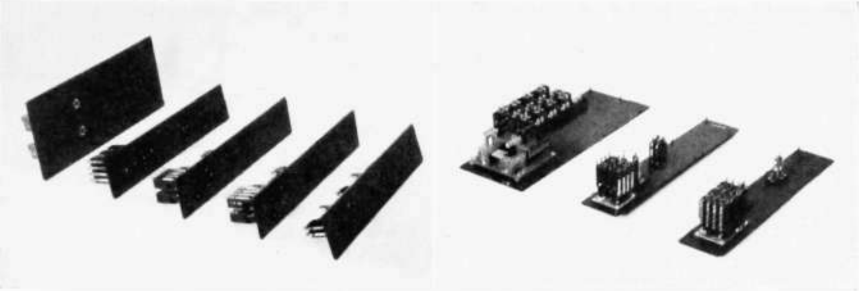


Fig. 3 & 4 X 7273
Insets
left, front views; right, back views; extreme left in both illustrations, insets of double width

as a rule dependent on the lay-out of the station. Moreover the apparatus were usually ordered one at a time and the turnover was not of such a size as to make re-designing a paying proposition.

The position was quite changed, however, when the Swedish State Railways, after thorough consideration of the advantages and disadvantages of the press-button interlocking machines, ordered 25 press-button switchgear plants all together in the autumn of 1941. This made it possible to undertake a thorough redesigning of the apparatus in order to eliminate as far as possible all troubles that had arisen.

One of the new apparatus, intended for Nälden station, is shown in Fig. 2.

A number of openings — in this case ten — have been provided in the front plate. Each of these openings, which have a height of 425 mm and a width of 80 mm, is covered by a plate, known as an inset. These insets are so constructed that any inset can be fitted in any opening whatever. There is one exception to this rule, in that a number of insets which are fitted with certain mechanical devices have been made with a width that is two or three times the normal width.

Fig. 3, 4 and 5 show a number of different insets. On Fig. 3 and 4 can be seen right to the left an inset of double width. Such an inset carries two control locks equipped with contact devices. These locks are mechanically dependent on each other through a rod which moves forwards or backwards when the bolt of the far lock moves up or down. In this position, the reverse of that shown on the illustration, the rod blocks the bolt of the nearest lock. Fig. 4 and 5 show how the insets are attached to the interlocking machine cabinet.

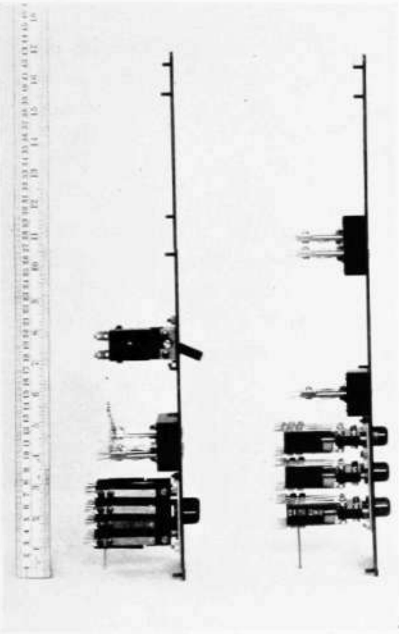


Fig. 5 X 4208
Insets
viewed from the side; the left-hand inset intended for operatin and indicating level-crossing booms, the right-hand one for two-light signal

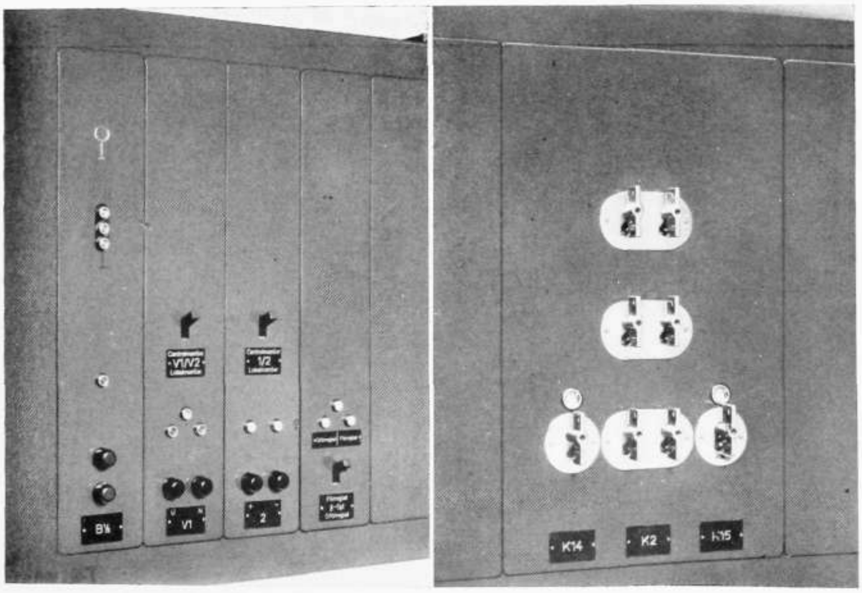


Fig. 6 & 7 X 5907
Insets fitted

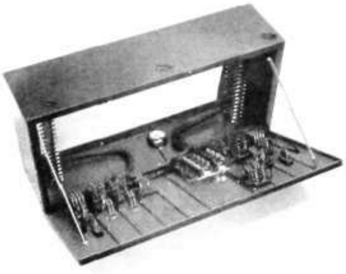


Fig. 7 X 5908
Press-button interlocking machine with front let down

On the edge of the plate may be seen the welded fixing screws. The two right-hand insets on Fig. 4 are reproduced in Fig. 5 as viewed from the side. The lefthand inset on this fig. is intended for operating a pair of drop barriers. It carries a double press-button for operating a lamp strip with three lamps for indication and a switch for permitting local operating of the gates. The right-hand inset is intended for operating a two-light signal. It carries three single press-buttons for operating, a lamp strip with one lamp which shows whether the train route concerned is locked or not and a lamp strip with two lamps for repeating the signal lights.

The three insets described above may be regarded as representative of current types. The devices on an inset are restricted to single and double press-buttons, lamp strips with one to five lamps, one or two way switches and control locks with or without contacts.

Fig. 6 shows part of one of the interlocking machines intended for the State Railways. As may be seen the insets have been freed from all visible screws. All operating and indicating devices are attached to the insets by means of screws welded on them.

Of the five insets shown on Fig. 6, that furthest to the left serves for the operation of a three-light entrance signal, the next for operating a pair of drop barriers, then one for switching a set of points and the last for locking a number of points and block sections. Far to the right may be seen a reserve position covered by a dummy plate. On Fig. 7 is shown an inset with width corresponding to three openings and carrying a control lock *K2* for locking points and block sections together with two other control locks *Kl4* and *Kl5* with contact devices, the former for unattended operation and the latter a train route lock. Mechanical dependence is arranged between the different locks.

Fig. 8 shows another of the apparatus included in the delivery to the State Railways, with front let down. As may be seen the connections are conveniently arranged with leads to the terminal blocks located at the ends, to which on mounting the circuits from relays etc. are connected. The interlocking machine of the type described are made in two sizes, a small one, Fig. 2 and 8, with space for ten and a larger for sixteen insets. Fig. 9 illustrates a large interlocking machine intended for Håkantorp station.

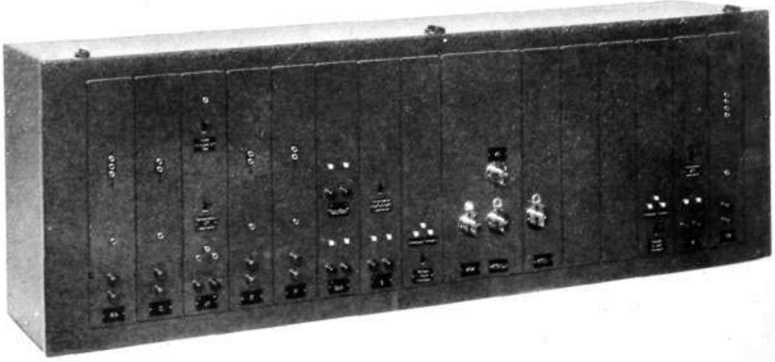


Fig. 8 X 5909
Press-button interlocking machine of large type with space for sixteen insets

Street Traffic Signal Plant with Impulse Coils

NELS FORCHHAMMER, L M ERICSSON A/S, KØBENHAVN

U.D.C. 656.05

For many years Dansk Signal Industri A/S, Copenhagen, in collaboration with L M Ericsson's Signalaktiebolag, Stockholm, has been working on street traffic signal plants. In 1933, the company executed the plant at Frederiksberg, which aimed at the best possible adaptation to the traffic by making the different signals dependent on each other by synchronizing. It was arranged for the traffic on the main streets to proceed according to a »driving plan», enabling drivers who maintained a fixed constant speed to meet green lights at a number of successive crossings, see Ericsson Review No 3, 1936.

In recent years a different principle has been introduced, whereby the signals are wholly or partially operated by the vehicles themselves. The system has obtained considerable application in the big cities of America and Britain, and it has been found that the main streets of these cities with their enormous traffic are better utilized when the timing of the signals is automatically adapted to the needs of the traffic.

As regards Copenhagen, there are no traffic problems approaching in magnitude a city like London, but there are other questions that make the matter of such signals important, including the question of safety at times when traffic is small.

The first signal constructed by Dansk Signal Industri for vehicle operation is specially designed for such conditions, as it is a type particularly suited for employment where a main street with heavy traffic is intersected by a street with traffic which, though small, is appreciable — at least at certain times of the day.

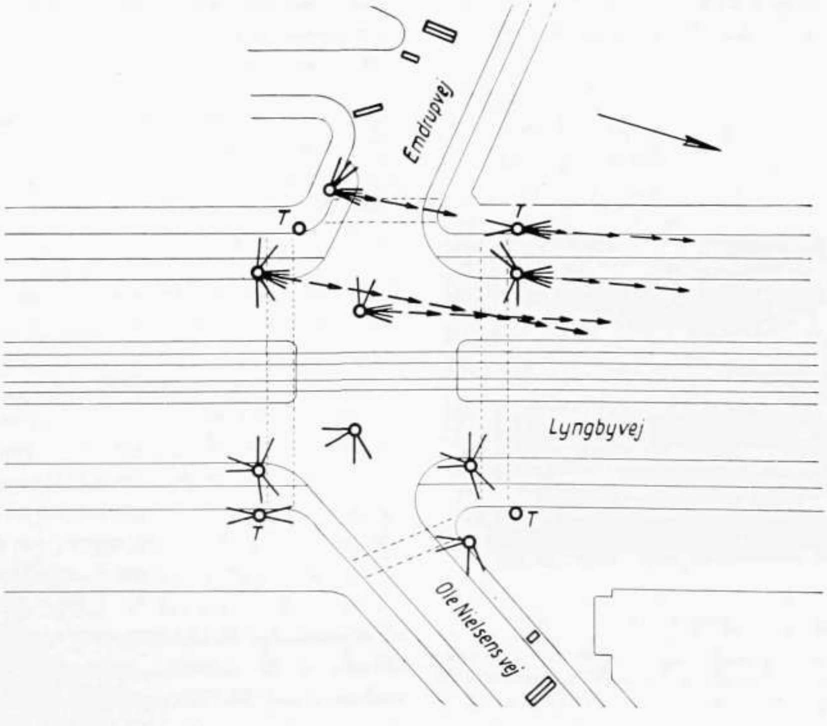


Fig. 1 X 5671

Lay-out plan for signal plant at Lyngbyvej

The impulse coils in the side-streets are single coil in the cycle tracks, in the roadway double coils dependent on direction; for north to south traffic arrows indicate how the different signal lights with their individual setting together give good sight over the whole width of the roadway

T press-button for pedestrians

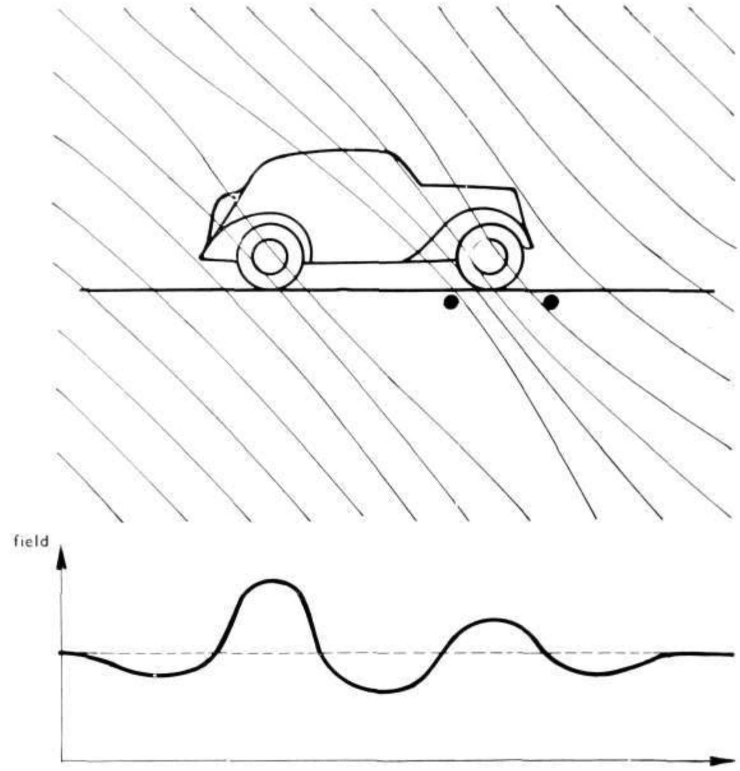


Fig. 2 X 5647 X 5648

Principle of the impulse coil's operation

above, distribution of the lines of force of the earth field in a motor vehicle's steel mass; below, variation of the field through the coil as the vehicle passes over

The Impulse Coil

The first signal plant of this type was delivered early in 1939 and installed at the crossing of Lyngbyvej (main street No. 3) and Ole Nielsens Vej (to the east) — Emdrupvej (to the west), Fig. 1. An essential feature in this plant is the special impulse device, the impulse coil. In place of a street contact, where a mechanical action by the vehicle is converted to electrical contacts, a purely electrical inductive action on a buried coil is employed. As a motor vehicle passes, its steel mass acts on the earth field through the coil, inducing a current in it, see Fig. 2, which actuates the connected impulse relay. By way of an accessory relay this operates the remainder of the signal mechanism. The sensitivity can be so regulated that either vehicles and cycles or vehicles only will actuate the relay.

The principle here applied was published by *A O Malvig* in 1930. In the years since then the system has been employed in a large number of traffic counting plants (including the experimental highway at Roskilde and the Little Belt, Storstrømmen, Guldborgsund and Oddesund bridges) and has proved itself in practice.

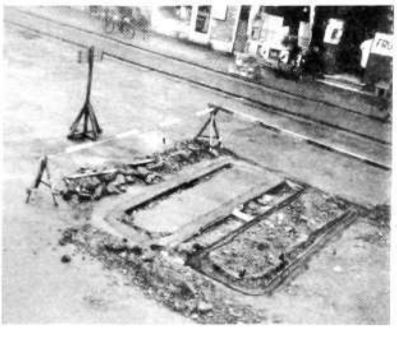


Fig. 3 X 3979

Laying of impulse coil

one coil is lying in the excavation, 4—6 cm below road level; the other is already embedded in concrete

One advantage of the impulse coil is that no moveable parts lie in the roadway; the coil is embedded in concrete, after which it is covered by the surface material of the road, see Fig. 3. Thus there is no possibility of rain penetrating it or snow or ice affecting it. As the whole of the energy serving the relay is produced inductively, there is normally no tension in the coil; the tension on passage of a vehicle takes some few millivolts, so that no insulation troubles arise with the parts embedded in the road. No part of the contact devices comes above the road surface; even though with mechanical contacts this may be only a matter of millimetres yet it is an advantage to avoid it. There is no wear on the parts in the roadway; the coils lie 4—6 cm below the surface of the road, which can be relaid without disturbing them. The fitting is simple and subsequent adjustment is not required should the roadway settle or be displaced; for mechanical contacts, on the other hand, a firm foundation must be provided and the part above must be accurately adjusted to the contact.

The impulse coils of the two side-streets to Lyngbyvej are single coils in the cycle tracks, as traffic here from its nature is one-way. In the roadway double coils are used, these having direction effect, so that only vehicles moving in the direction of the crossing are recorded.

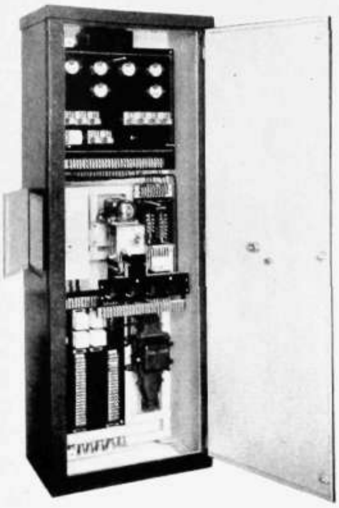


Fig. 4 X 3980

Instrument cabinet for roadway control

top, relay equipment; middle, motor-driven control apparatus with four buttons for regulating signal timing; bottom, fuses and terminal strips for connection of cables

Instrument Cabinet

The chief feature of the system is the sensitive relay which receives the induced impulse from the coil. It is constructed with a moving coil system and a special contact device. All the other auxiliary and time relays in the apparatus operate with weak current, 12 V, supplied by a built-in rectifier. All these components therefore are assembled along with the impulse relays on a common panel at the top of the cabinet, Fig. 4. When the cover of the panel is removed the whole relay equipment can be lowered outwards for inspection of the connections at the back or it can be taken out altogether if the clamps at the bottom are loosened.

The contacts for the lamp circuits are served by a motor-driven control apparatus fitted in the middle of the cabinet. The motor runs at the same tension as the lamps; it receives control impulses from the roadway controls, but is otherwise independent of them, so that the signal plant, in case of failure or when the roadway controls are being inspected, can operate undisturbed with the apparatus set for fixed times. The plant can also be operated manually by inserting a handle.

The time-setting of the control apparatus is done by resistances; by means of four buttons at the front separate times can be set for »Green light main street», »Yellow 1», »Green light side-street» and »Yellow 2». Setting can be done during operation.

Exactly the same control apparatus can be employed without roadway operation for general operation with fixed signal times, Fig. 5. The apparatus can, moreover, be arranged for any signal colours whatever, *e. g.*, red—yellow—green—yellow or red—red + yellow—green—green + yellow and so on.

At the bottom of the cabinet there are the terminals for connecting power current, *i. e.*, for lamps, control apparatus and the rectifiers which deliver D.C. for the auxiliary and time relays.

The cabinet itself is locked with the key used by the public lighting supply employees, as it is only to be opened for inspection and repair. The various controls to be operated by patrolling constables are assembled in a box built in the cabinet at one side and which the police can open. In this are a main switch for 220 V, a switch for automatic or manual control, a switch for roadway or general operation, a handle to be inserted for manual operation and directions for use.

The plant is generally lit up during the whole twentyfour hours, as it is just the night traffic on the main street with high speeds that is dangerous at the crossing. At present it works with the following timings: the signal normally shows green light for Lyngbyvej; there are no impulse coils installed in this roadway as it is reckoned there will always be traffic on it. A vehicle coming on one of the side streets changes the signal to the side streets in 5 s from yellow to green, which signal remains for 20 s; the time must be so long, as otherwise it would be difficult for cyclists to get across.

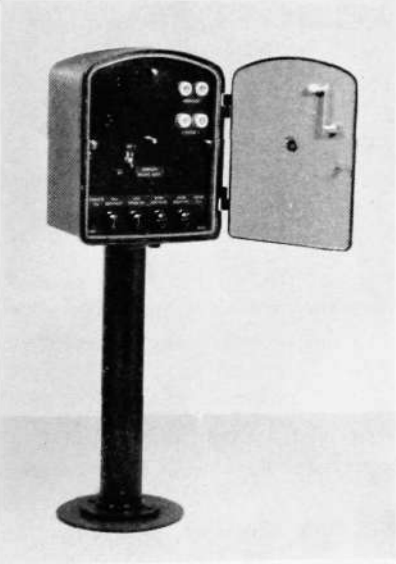


Fig. 5 X 3981

Control apparatus for fixed signal timing

fitted in cast iron cabinet for use without roadway operation

When the signal returns to green for the main street, there starts a block period during which it cannot change. This period is at present different for motor vehicle traffic than for cyclists and pedestrians; the periods are 40 s

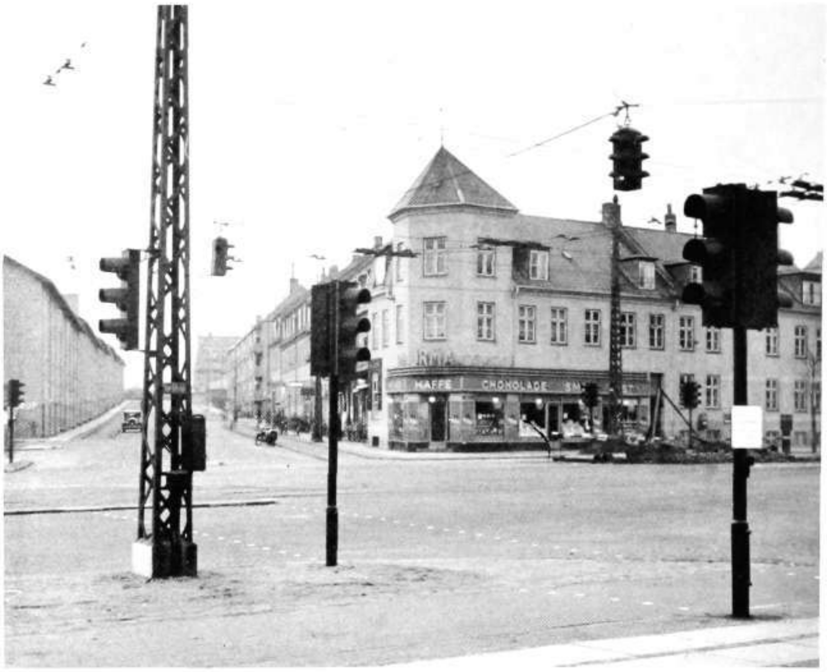


Fig. 6 X 5637

Different forms of mounting signals

In the foreground, fixed signals mounted singly or in groups on lamp-posts or on separate poles, right, pole with press-button for pedestrians; above the roadway suspended multi-sided signal units

and 70 s respectively. To ensure against vehicles being caught (e. g. delivery trucks making a stop between the coil and the stop line) and to give pedestrians »stranded» on the refuges in the middle of the main street a chance to proceed, the signal is further provided with a reserve time fixed at 120 s, so that even when there is no traffic in the side-streets green light is given for them every 2.5 min. The different times can be regulated separately; thus if inconvenience is caused by the special time to waiting cyclists this can be made shorter, or possibly set for the same period as the waiting time for cars.

The Signals

In putting up the signals the greatest possible attention has been devoted to ensure clear and unmistakeable signal indications for the different streams of traffic, a difficult matter especially in the wide main street (36 m from curb to curb). All signals are arranged individually at the angle giving the best visibility for the traffic stream concerned. The signal units may be mounted in different manners and in various combinations, see Fig. 6 and 7. The opening of the signal is 200 mm and it is fitted with reflector and spreader; each signal has a 40 W lamp of standard street lighting type.

On some of the signal poles a press-button is mounted, by means of which a pedestrian can attract attention. Similar buttons are also mounted at a couple of places on separate stands. To supplement the signals there are suspended above the road crossing two double-sided sets of signals.

Besides the main-street signal plant here described, Dansk Signalindustri A/S also make vehicle-operated signals of other types. The most universally employed type is made with coils in all the meeting streets and can be used, for instance, for crossings with heavy traffic in both directions, especially if the traffic varies in the different directions according to the time of the day; the same system finds employment where signal plant is to be set up with the particular object of utilizing the »go» time to the last second, as in the case with traffic arteries which are decidedly overloaded for shorter or longer periods.

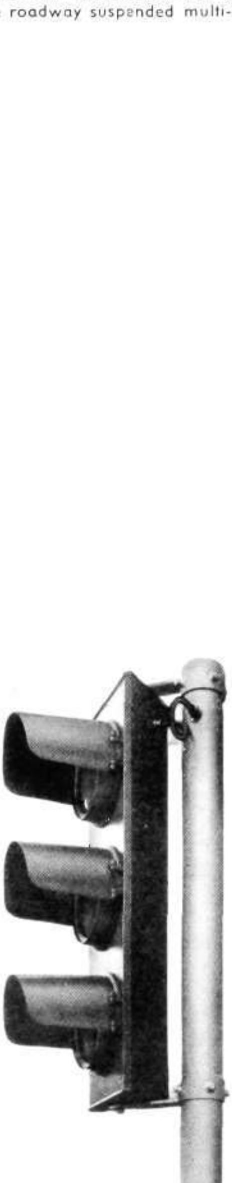


Fig. 7 X 3982

Signals mounted on a pole

Interlocking Plant at the Bascule Bridge over the Falsterbo Canal

T LUNDBERG, ENGINEER, ROYAL RAILWAY BOARD, STOCKHOLM

U.D.C. 656.216.2+656.25

In conjunction with the construction of the Falsterbo Canal and the bridge over the canal for railway and highway traffic to Falsterbo there was arranged an interlocking plant. The plant was ordered by Mr. Rudolf Kolm, chief of the bridge building section of the Highways and Waterways Board, from Signalbolaget and was put into service in April 1941. The interlocking machine comprised in the plant is a relay interlocking machine (or press-button interlocking machine).

Owing to the difficult shipping conditions that arose through the blockade of shipping around Falsterbo Head, the Swedish Riksdag decided that a canal should be cut through the narrowest part of the Falsterbo isthmus to provide passage for shipping which would otherwise have to go round Falsterbo Head.

As this canal would cut across both highway and railway to Falsterbo a bridge had to be provided. The nature of the ground was such that a high-span bridge could not be arranged to advantage and it was necessary to have a bascule bridge. A readymade bridge was purchased, the wellknown Knippels Bridge of Copenhagen which had been replaced by a wider bridge necessitated by the needs of the traffic. As the bridge bought is not wide enough to allow the railway track to run alongside the highway it has been necessary to lay the track in the roadway. Railway and road traffic, therefore, must proceed alternately across the bridge. Obviously the railway and road traffic must be stopped to give passage to ships necessitating the raising of the bascules, Fig. 1.

Drop barriers and illuminated signals have been provided for barring the road traffic, see Fig. 2. The barriers are operated by electric winches, fixed directly on the frames. The illuminated signals *L* show white flashing light when the bridge is free for road traffic, otherwise red flashing light. In addition lowlying signals *G* have been placed close to the foot-walks immediately in front of the bascule, these showing red light when the bridge is raised.

To make the vehicles keep to the left half of the road in the bridge area, traffic dividers have been set up in the middle of roadway immediately outside the barriers.

For stopping the railway traffic illuminated home signals *A* and *B* have been arranged, these showing fixed red light when the bridge is given up to road traffic or the bridge bascules are locked in raised position, and fixed green light when the route is clear for railway traffic. Owing to the track making

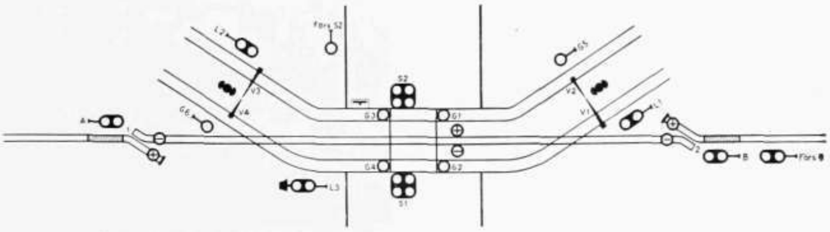


Fig. 1
Lay-out of the plant

X 5891

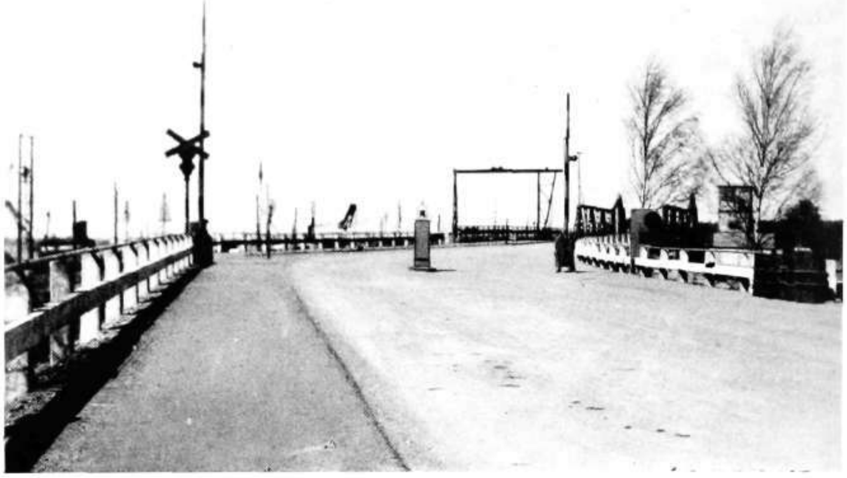


Fig. 2 X 5803
Lifting gates, illuminated signals and traffic dividers
at the entrance to the bridge

a curve in front of signal *B*, so that signal is only seen at a comparatively short distance, the distant signal *B* has been arranged. Inside the signals *A* and *B* electrically operated safety points have been laid, which take up protective positions when the bascule is up. Outside the safety points, insulated track sections are arranged, used for track locking and for point locking. The track locking is cleared only when the train has passed the last insulated section in the direction of its passage. When the bridge is to be opened, in order that the bascule be locked, the safety points must take up protective positions, the home signals *A* and *B* show fixed red light, the barriers be down and the signals *L* show red flashing light.

Water traffic is regulated by two illuminated signals S_1 and S_2 (signal S_2 has a distant signal at the south canal entrance), constructed as position light signals with four points of light. These signals are set up at either side of the pillar that carries the bascule. By means of these signals »stop», »tie up at quay» and »free passage under the bridge» can be signalled. The signal indications consist of two uncoloured lights, together forming the signal aspect. »Stop» is two lights side by side in horizontal line. For signal indication »tie up at quay» one light lies 45° to the right above the other. In the signal indication »free passage» the lights lie one above the other. All these indica-

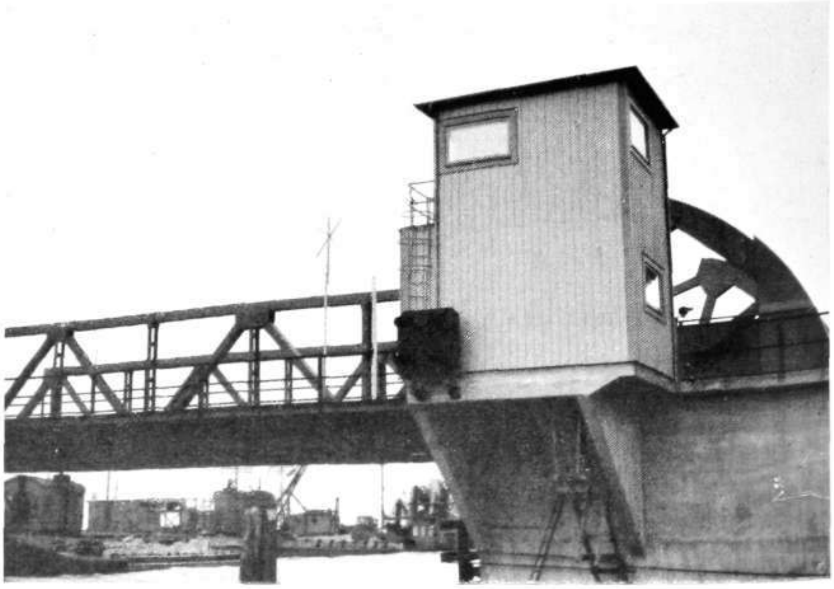


Fig. 3 X 5814
Control tower of the bascule bridge

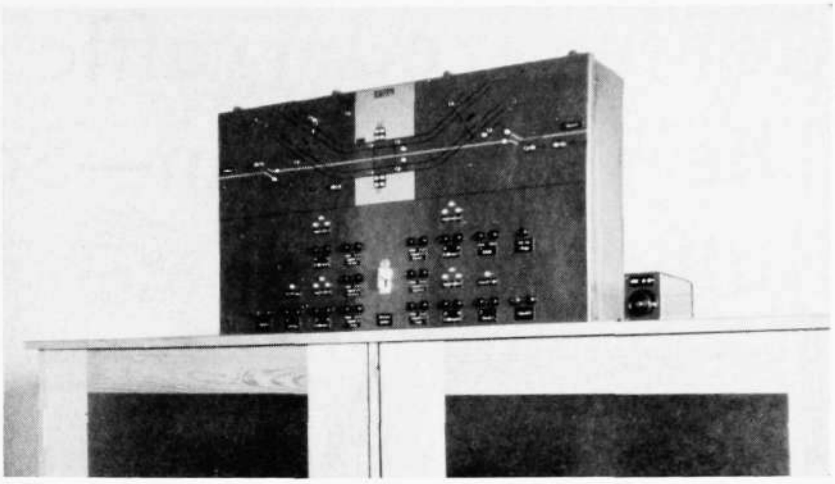


Fig. 4 X 5804
Interlocking machine
with press-buttons and illuminated diagram

tions are either flashing or fixed. The flashing signal indication is preliminary to the fixed indication which is the execute signal.

The signal indication »free passage» can, when the bridge bascule is raised, only be given by one signal at a time. »Stop» and »tie up» can be given no matter what indication the opposite signal may give or what position the bascule may be in.

For the operation of the above-described devices an interlocking machine is fitted in the bridge control tower, provided with press buttons, see Fig. 4. The buttons actuate relays, which in turn operate points, signals, lifting gates and locking motors. Relays are likewise used for indication and interlocking. On the upper part of interlocking machine there is arranged an illuminated track diagram, showing in miniature the canal, the highway and the railway line, as well as points, barriers and signals. All the signal indications together with the positions of points, locks and barriers are indicated by lamps.

For the interlocking plant three-phase alternating current is taken from the power network which feeds the bridge machinery and this current is transformed or rectified for the different apparatus. A three-phase generator driven by an internal combustion engine is installed as reserve power feed. If the power feed fails, the bascule bridge must be operated by a reserve internal combustion engine which is coupled to the bridge pinion gear by a claw clutch. This clutch is locked by a control lock in such a way that the key, normally under lock on the interlocking machine, sets all signals at »stop» when it is removed from the interlocking machine. In addition the clutch lever of the engine is locked in disconnected position by a magnetic lock, which cannot be unlocked until all electric interlockings have been set for the raising of the bascule.

Centralized Traffic Control on The Stockholm—Saltsjöbaden Railway

H MONTELL, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

U.D.C. 656.257 (487.1)

In recent years systems of the kind described below have found increased employment abroad, especially in USA. In Sweden a plant of this type was delivered in 1938 by L M Ericssons Signalaktiebolag to the Stockholm—Saltsjöbaden Railway. The plant which has now been in service for 6 years with good results was developed in consultation and under the supervison of Mr. T. Hård, departmental chief in the Royal Swedish Board of Railways. The account which follows was published in Nordisk Järnbanetidskrift, with whose kind permission it is reproduced.

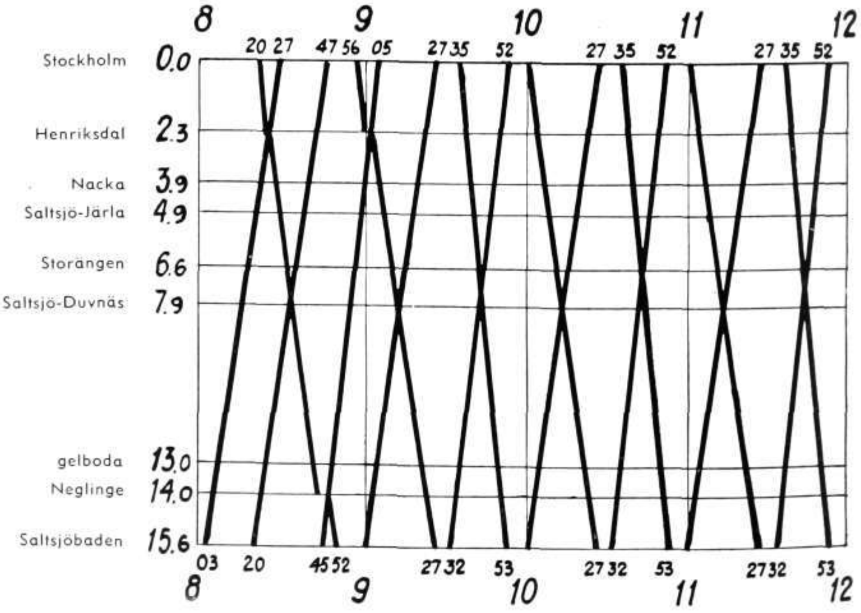
Since the spring of 1938 there has been in service on the Stockholm—Saltsjöbaden Railway a plant for centralized traffic control on the CTL system. The railway, which connects Saltsjöbaden with Stockholm, has a length of 15.5 km and runs through several densely built up communities, also serving some large industrial centres.

Traffic on the railway is dense, with one train per hour in each direction. In addition there are supplementary trains at certain times of the day, in to Stockholm in the morning and back from Stockholm in the afternoon.

From the graphic timetable shown in Fig. 1 it may be seen that the trains start from the two terminal stations at practically the same time.

The line is single-track except for the sections Saltsjö-Duvnäs—Storängen and Järla—Nacka, which are double-track. Train crossings are for the most part confined to the section between Saltsjö—Duvnäs and Storängen. In certain cases, however, trains cross at Henriksdal station.

Fig. 1 X 5577
Graphic timetable
for the Stockholm—Saltsjöbaden railway



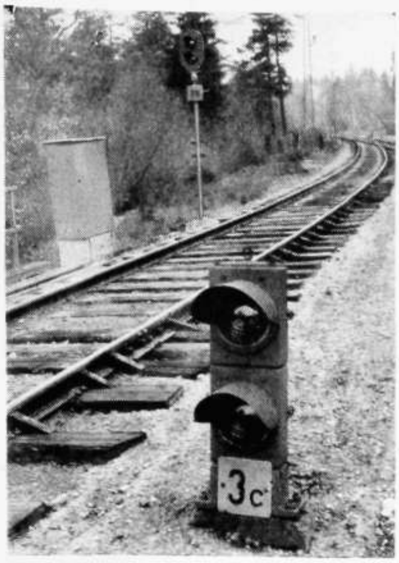


Fig. 2 X 4361
Illuminated signal

The line is elektrified for D.C. current, with 1300 V operating voltage. The stations had mechanical locking machines.

In the beginning of the 1930s the question became urgent of a thoroughgoing reconstruction and modernising of the interlocking plants at the different stations, with the object of rationalising operation. Various proposals were considered and finally the following decision was reached, which was regarded as the most suitable from all points of view.

The whole line should be furnished with automatic line blocking.

All barriers should be let down automatically by trains approching and be automatically lifted immediately the train had passed the level crossing. In one case existing automatic bell ringing should be retained.

The stations of Saltsjö-Duvnäs, Storängen, Järla, Nacka and Henriksdal should be distance controlled from a control centre located at the depot station Neglinge.

The work of reconstruction at the stations which were to be distance controlled was put in hand in 1937. The existing mechanical locking machines (crank apparatus) were replaced by completely electric locking plants.

Construction

The semaphores and in some cases the existing illuminated signals were replaced by up-to-date illuminated signals; the points on the main tracks were provided with electrical point machines; on the sections between the stations and on the main and meeting tracks at the stations track circuits were arranged. A number of level crossings were supplied with new barriers and all of them were equipped with electric operating devices. Those points and scotch blocks that were not furnished with electric operating devices were equipped either with locks, the keys for which are kept under lock and key at each station, or the points and scotch blocks were locked from existing crank apparatus which are kept locked.

The newly installed *illuminated signal lights* are of up-to-date construction with double lens system. The entrance signals have 2 green and 1 red light, the exit signals 1 green and 1 red light. The lamps of the entrance and exit signals for the main line tracks are mounted on poles or suspended in the power line suspension bridges, so that the signal lights are about at eye-level for the engine-drivers. Exit signals for side tracks, on the other hand, consist of low illuminated signals mounted direct on concrete foundations alongside the track, see Fig. 2. This placing of the illuminated signals at different heights in relation to the track is due to the desire to distinguish them in a marked way and thus prevent any confusion.

The *point machines* are of Signalbolaget's standard design, equipped with tongue control and built-in point lock, and driven by 220 V three-phase motors.

The *barrier machines* also are provided with 220 V three-phase motors.

The *track circuits* are made as A.C. track circuits and are fed by 50 c/s A.C. For track relays there are used two element two position vane relays. The track feed is done over transformers and the track current is regulated by shift resistance. The relay transformers are connected between the tracks and the relays.

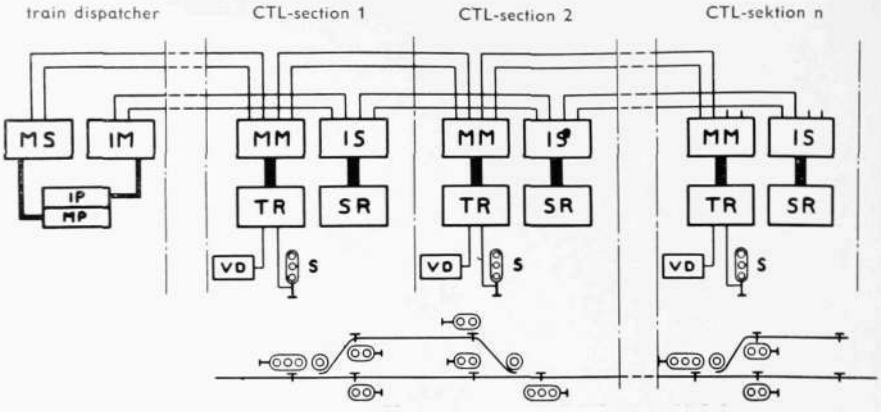
Distance Control System

The operating centre from which the distance controlled stations are controlled and supervised is located at Neglinge. The centre comprises a control apparatus and the control transmitters and indication receivers cooperating with it.

Fig. 3 X 5975

Diagram of the distance control system lay-out

IM	indication
IP	illuminated diagram
IS	indication transmitter
MM	contol receiver
MP	control panel
S	signals
SR	track relays, point indication relays
TR	train route relays
VD	point machine



A telephone cable has been laid along the whole line. Two wire-pairs in this cable are employed for the distance control system, two pairs for telephone purposes and the remaining pairs for the automatic line blocking and other purposes.

The operating centre at Neglinge is connected, via the two wire-pairs employed for the distance control system, with CTL-sections, one at each of the stations Saltsjö-Duvnäs, Storängen, Järla and Nacka. Each such CTL-section comprises a control receiver and an indication transmitter. In addition two CTL-sections have been connected at Henriksdal station to the wire-pairs, as this station is too large to be conveniently served by a single section. Fig. 3 shows the lay-out in diagram of the distance control system.

By means of the operating apparatus the train dispatcher stationed at Neglinge sets and starts orders wanted (train routes and the like) to the different stations, where the orders are received in the control receiver. These in turn actuate special order relays which take care of the execution of the orders. Everything is done completely automatically, so there is no need for any staff at the stations to allow entrance and exit of trains or for regulating the run of the trains between the stations.

Through the indication transmitters communications are transmitted from the different stations to the control centre, when trains enter and later leave the different track circuits, of the positions of points, whether barriers are up or down etc.

In this way the running of the trains is arranged and the situation at the different stations are supervised from the train dispatcher position.

It has not been the intention with the distance control system to provide interlocking in the ordinary sense, i. e., the dependence between points and signals. This has been provided for by the local interlocking plants at the stations and by the automatic line blocking.

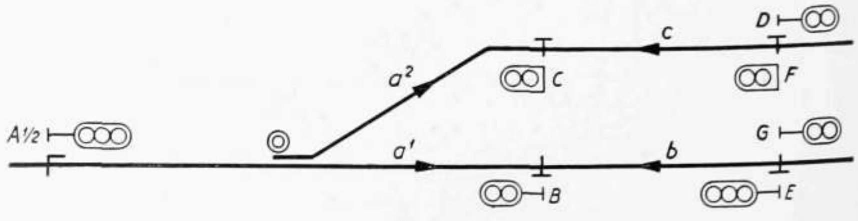
The characters of the distance controlled stations on the Stockholm—Saltsjöbaden line are such that it has been possible to make them practically alike as regards control.

Fig. 4 shows in principle how the stations are arranged. In view of the existing double track it has been possible to arrange automatic signals on the sections between Saltsjö-Duvnäs and Storängen and between Järla and Nacka. The automatic signals always show clear if line sections before them which they are to protect are free from traffic and any barriers along them are

Fig. 4 X 5976

Track lay-out in principle at station

A 1/2	entrance signals
a^1, a^2, b and c	train routes
B	exit signal for straight track
C	exit signal for side track
D, E, F and G	automatic signals



down, provided that conflicting train routes have not been set from the control centre at Neglinge. The first thing that happens when an order for a fresh train route from Neglinge comes into a station is that the previous order is cancelled. Then the points comprised in the train route are shifted automatically, if they are not already in correct position, after which the setting of the signal to clear is prepared. If there is no level crossing before the signal along its protection stretch and if the stretch is free the signal goes to clear at once. If there is a level crossing on the section clear signal is not given until the barriers are down. Conflicting train routes cannot obviously be ordered simultaneously.

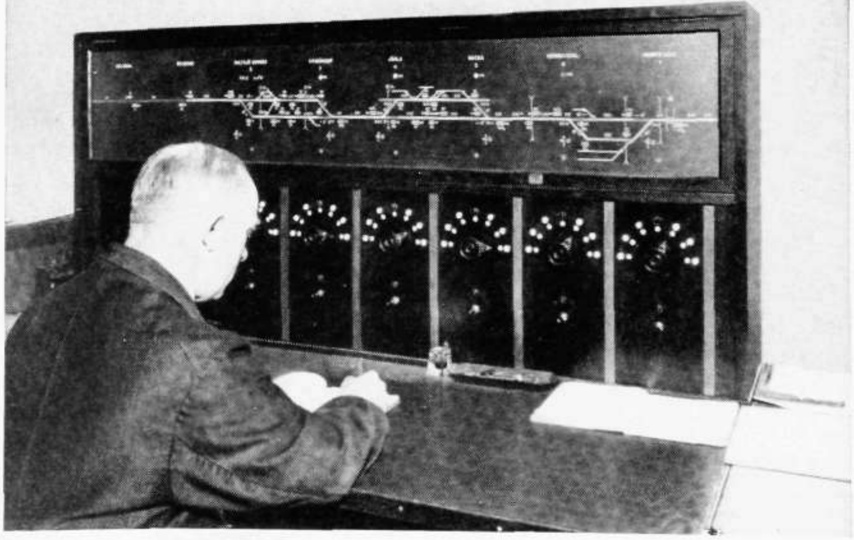
Train route locking has been introduced and makes it impossible to alter a train route laid if a train is approaching. If there is a train on the block section and it is absolutely necessary to re-arrange the train route, this may be done by the sending out from Neglinge of a special order for terminating the train route locking that has been made. The distance operated signals at the station will then show danger. After the lapse of a certain time, regulated by a time relay, the train route locking is released automatically. The new train route can then be arranged. Signals applying to entrance from opposite directions to the same block section cancel each other out.

Control Centre

The control apparatus installed at Neglinge, shown on Fig. 5, comprises a control panel, provided with six fitted control fields and 2 reserve fields, viz: one control field for each CTL-section. The control fields, identical with each other, are fitted with a control knob with necessary order lamps, a starting button and a lamp to show faulty signalling. By means of the control knobs which have 7 setting positions the following order settings can be made:

1 train route a^1: entrance on straight track
2 » » a^2: » » side track
3 » » *b*: exit from straight track
4 » » *c*: » » side track
5 *L*: order permitting local operation of points
6 *A/B/C stop*: order cancelling train route locking introduced
7 *p*: test starting of indication transmitter. The start button is used to start order sending after the control knob has been set.

Above the control panel an illuminated diagram has been arranged. This is made of etched glass sheets on which is shown a miniature of the CTL-operated railway line. The track system with its track circuits is made up of illuminated ribbon.



X 5977

Fig. 5
Control apparatus

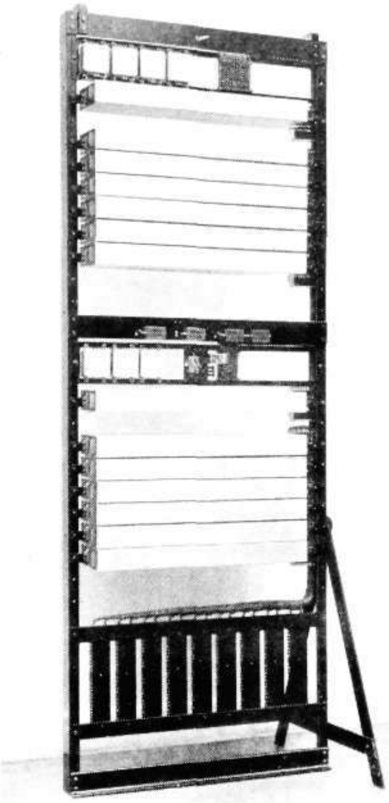


Fig. 6 X 4262
Relay and selector rack at Neglinge

In addition to the track circuits there are indicated the positions of the distance controlled points, the raised positions of the barriers, if the distance controlled signals A, B and C at the stations concerned show danger and if the master locks mentioned above as at each station and which lock the central lock or the crank apparatus respectively are really locked. Fig. 6 shows the rack with relay and selector equipment for the control transmitter and the indication receiver at Neglinge.

The control transmitter is equipped with relay devices for 6 CTL-sections, but the rack is cabled for 2 further sections, to allow of later enlargement to 8 CTL-sections, should that prove necessary. In the same way the indication receiver is constructed for receiving indications from 8 CTL-sections, though at present only fitted with relays for indication receiving from 6 CTL-sections. From each CTL-section indication can be given respecting the two positions of 10 devices.

The relays are mounted on bars. Each bar is provided with a fixed connecting plug, enabling the bar to be easily loosened and taken out of the rack for inspection or replacement. This is done without the necessity of loosening any connection. All connections of wires to the rack are made on a number of terminal blocks, mounted on the lower part of the rack.

Control Receivers and Indication Transmitters

As stated above, at each CTL-section there are control receivers and indication transmitters. These apparatus consist of a base-plate on which is fitted a relay grid. Relays and selectors are fitted on the relay grid, which can be swung out. The relay grid is connected to the base-plate by means of flexible connecting cords provided with plugs which are plugged into jacks on the base-plate. It is a simple matter to take the connecting cords out of the jacks after which the relay grid can be lifted and taken out for examination and if necessary for replacement by a reserve grid.

Fig. 7 shows a control receiver. The components comprised in the distance control system, such as relays and selectors, are parts wellknown in automatic telephony and to be found in the different automatic systems.

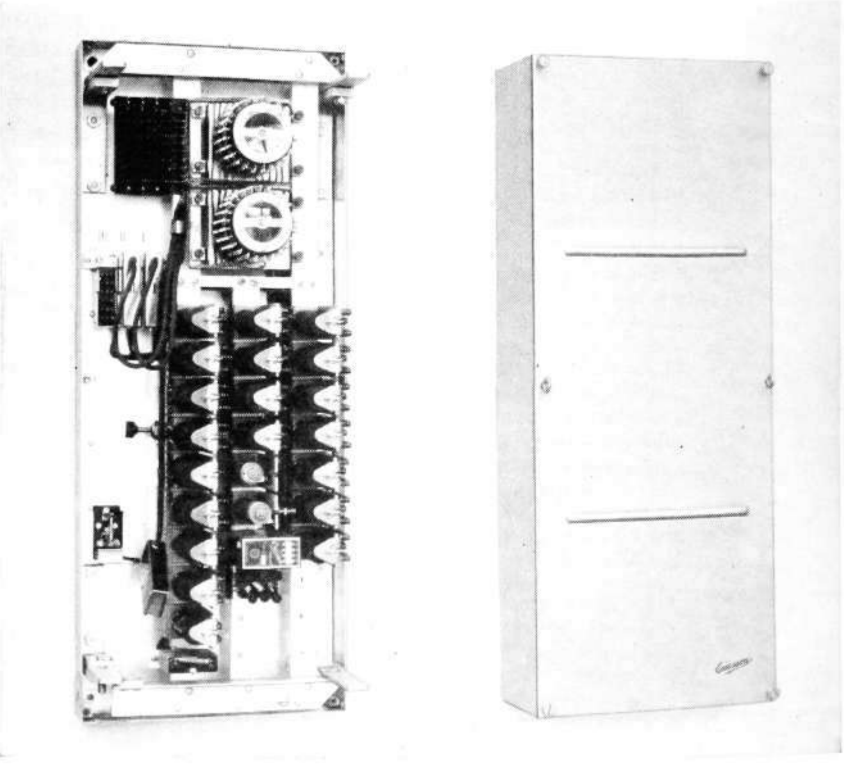


Fig. 7 X 5978
Control receiver
left, without cover: top, selectors, below, relay sets; rigth, with cover

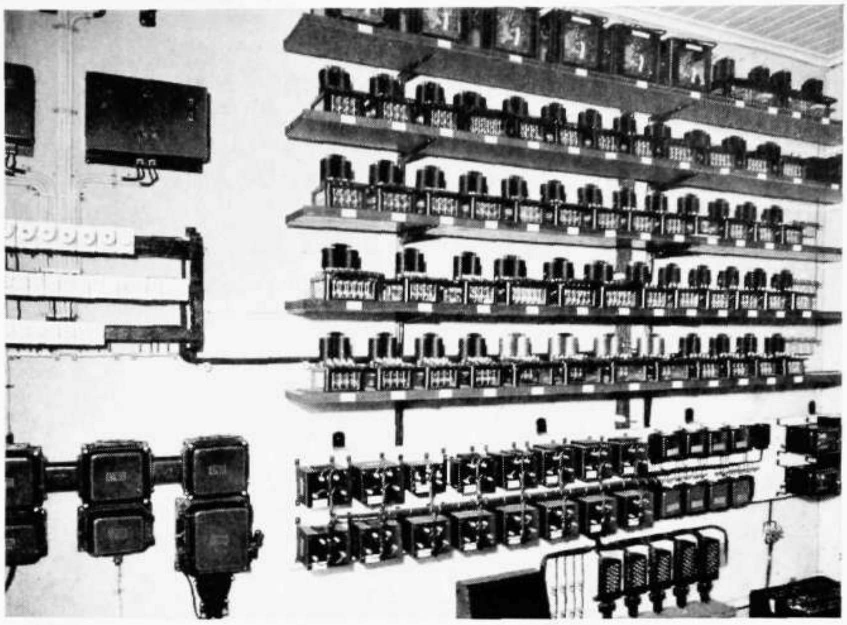


Fig. 8 X 5979
Inside view of relay room

At the different stations special relay rooms have been arranged in the station buildings. The relays required for the interlocking plants are arranged on shelves and transformers for illuminated signals and track circuits are put up either in the relay rooms or in small cabinets out at the different signals or insulated track joints. The CTL-apparatus are also mounted in the relay rooms. Fig. 8 shows an example of how the fittings are arranged at Saltsjö-Duvnäs station and Fig. 9 shows a relay cabinet.

Power Supply

For the line section Saltsjö-Duvnäs—Henriksdal the power supply for the interlocking plants is provided from a 3300 V three-phase network along the line. Power at Neglinge is obtained from a local 3 × 220 V network.

Outdoor transformers have been set up at the various stations and these transform the tension down to 3 × 220 V with secondary zero taken out. From this secondary network there is then tapped the power requirement at the stations for illuminated signals, point machines and barrier raising machines, relay equipments etc. For the CTL-devices there are used 24 V Nife batteries and for the relays of the interlocking plant 12 V Nife batteries. The batteries are kept constantly charged from metal rectifiers.

In projecting the work of reconstruction and the subsequent working out of details there was very close collaboration between the chief inspector of the line Mr. J. Andersson and Mr. T. Hård of the State Railways, acting a technical adviser and supervisor, on the one hand and Signalbolaget on the other.

The CTL-system as used for the distance control proper was worked out by Signalbolaget in conjunction with Mr. Hård. The system differs in essential parts from earlier similar American relay systems, among other things in the use of selectors as components as well as relays. The actual work of erection was carried out under the railway company's own management, with Mr. Hård as supervisor.

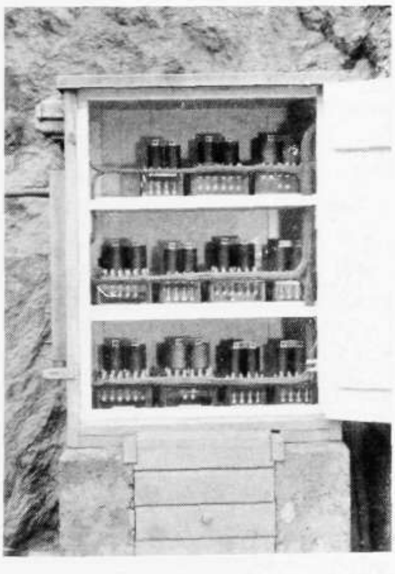


Fig. 9 X 4263
Relay cabinet

New Interlocking Plant at Stockholm East Station

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U.D.C. 656.257 (487.1)

The Stockholm—Roslagens Railways have for some years had a number of relay interlocking control machines (with press-buttons) in operation. As the traffic at the biggest station of this railway system, Stockholm East, had grown to such an extent that a complete reorganization of the whole station has become necessary and with it a new signal interlocking plant had to be constructed, the administration decided to equip the station with a relay interlocking control machine of Signalbolaget's manufacture. That this choice was made is due largely to the good experience obtained from earlier plants.

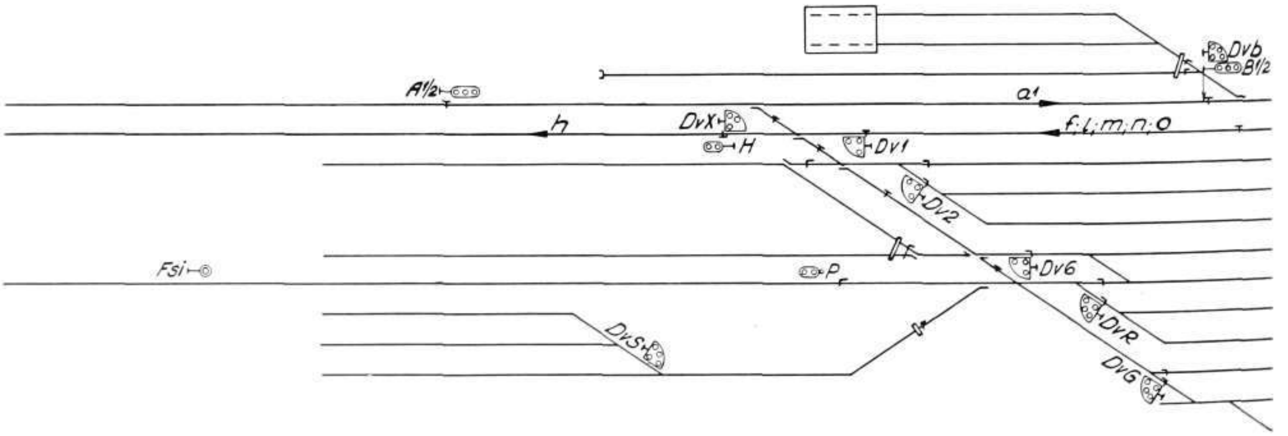
Stockholm East normally has to deal with about 180 trains per day of traffic, special trains and doubling excepted. Of these, 102 consist of local trains to and from Djursholm, 70 of passenger trains to and from Rimbo, Vallentuna and Österskär, the remainder being goods trains. All the Djursholm trains run on a special double track, see Fig. 1, which continues as a single track through Engelbrektsgatan for about 1 km into the city proper with terminus at Humlegården. The other passenger trains are distributed over tracks *II—V*, to be seeen on the figure below the Djursholm tracks. Goods trains are run as a rule to and from the goods yard over a side-track which cuts across the main tracks just inside the outermost signals.

X 7248
X 7247

Obviously the amount of traffic requires farreaching rationalization of the operation of the station while the demands of operating safety must not be neglected. The relay interlocking machine has been produced with the object of creating a type of interlocking machine which is so easily operated that the train dispatcher alone may be capable of handling both the interlocking machine and the train dispatching even for moderately large stations. The interlocking machine therefore must be so constructed that the train dispatcher from his office is not only in a position to keep an eye on it without trouble but, with the least possible exertion, can deal with its operation, Fig. 2. In addition he must have automatic control over all movements of trains and trucks and over the positions of signals on the station area.

Fig. 1
Track lay-out at Stockholm E

⊢◎◎◎ home signal with three lights
⊢◎◎ home signal with two lights
⊢◎ distant signal
⊢◔ dwarf signal
–┬– *insulated rail joint*
–▯– scotch block
⊡ signal cabin



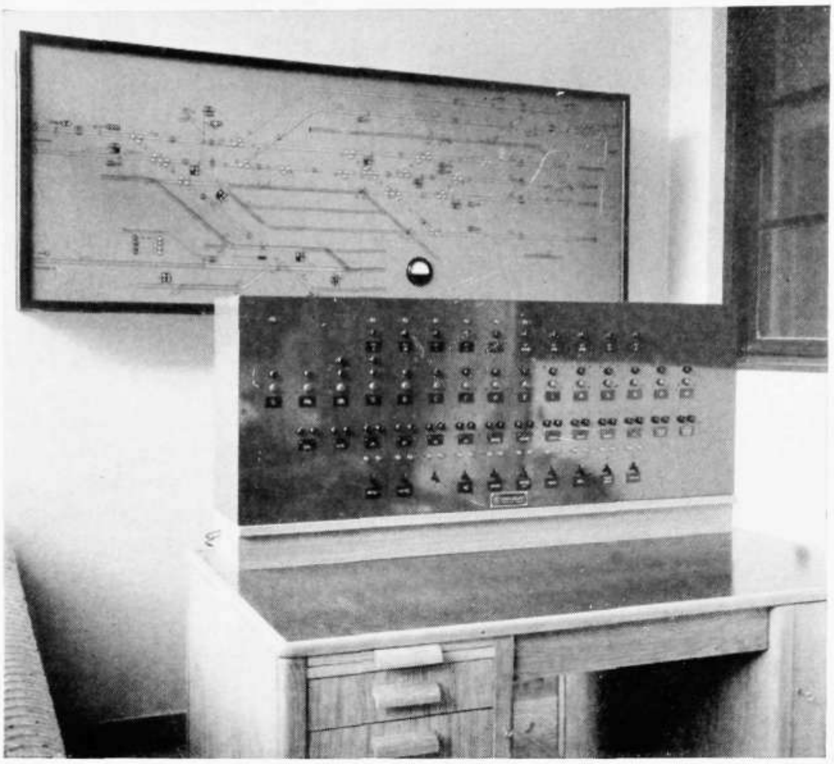
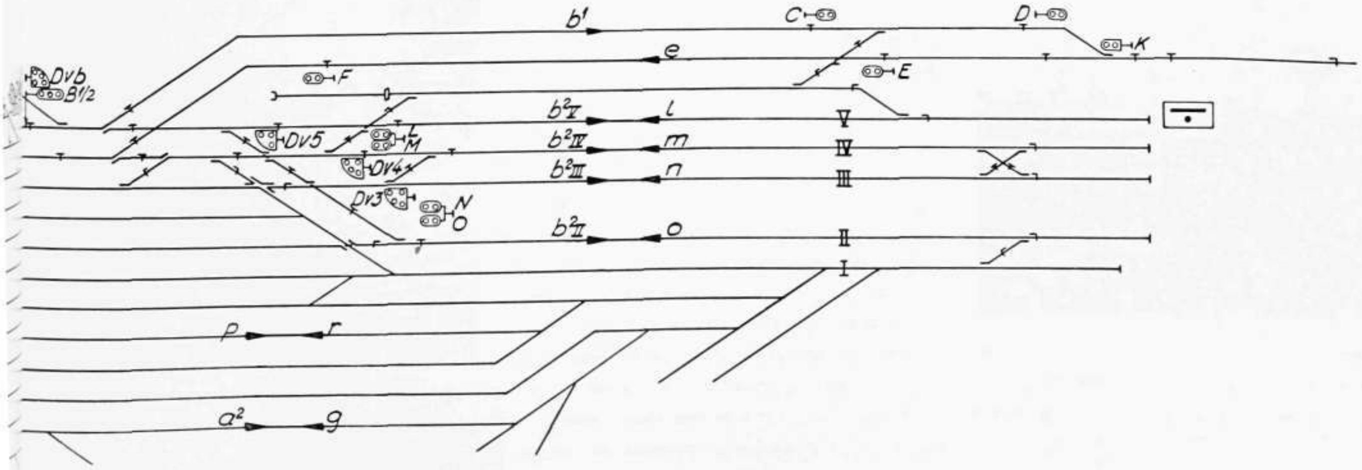


Fig. 2 X 5816
Interlocking machine and illuminated track diagram
located in the train dispatcher's office

The first of these conditions is fulfilled by the interlocking machine being constructed in very concentrated form with the simplest possible of operating devices, arranged in a manner that is surveyable and logical. Thus signals and points are operated by press-buttons and locking devices by small tumbler switches. The second condition is met by an illuminated track diagram. On this a number of goods tracks have been left out as these are not comprised in the locking, and truck movements can proceed to a limited extent on them without disturbing train movements.

Each illuminated signal that is governed by the train dispatcher's operations is repeated on the track diagram by a miniature pattern which reproduces its actual appearance. A small number of dwarf signals which are automatically dependent on nearby points etc. are not repeated in the signal patterns. In addition plus and minus position is indicated for all centrally operated points, whereby the train dispatcher can immediately check if certain routes are switched correctly. For those points which have both central and local operation the lamp which marks the point tongue or crossing point constitutes an indication of whether permission for local switching has been given or not. Normally the lamp shines but if permission for local switching has been given it is extinguished.



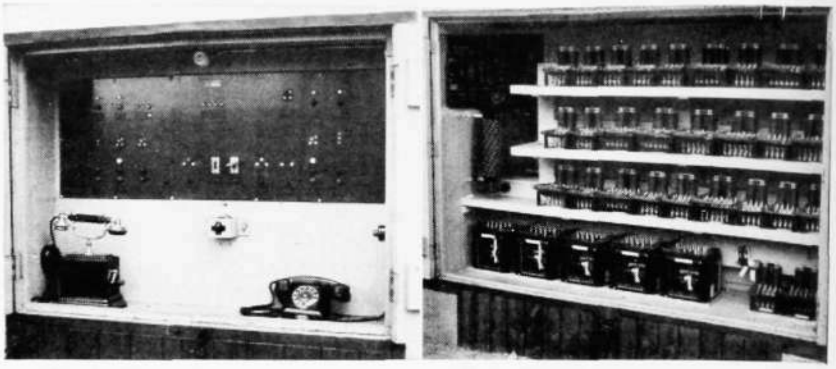


Fig. 3 & 4 X 7246
Local interlocking machine for the goods yard
left, control board; right, relay cabinet

All tracks which concern the train routes are divided up into a number of track circuits which are marked on the track diagram, each being there provided with a control lamp which shines with a pale blue light when the track circuit is free from rolling stock. The track circuit lamps have the purpose of informing the train dispatcher concerning train movements on the different tracks.

When the track circuit in which a centrally operated point is included is entered by a vehicle, the switching device of the point is blocked automatically by a contact on the track relay blocking the operating current circuits for the point's switching.

As at all terminal stations, the train routes at Stockholm E branch out fanwise from the main tracks, Fig. 1. Departure from this rule occurs, however, owing to the necessity of giving the Djursholm tracks an exceptional position due to the special traffic on them and because the goods yard has received a direct entrance and exit train route. The branching of this train route requires a first entrance signal *A*½ and the separating of the Djursholm trains from the other passenger trains another entrance signal *B*½. The Djursholm trains enter on signal *B1* and other passenger trains enter for one of four train routes on signal *B2*. The four corresponding exit signals *L*, *M*, *N* and *O* are combined with a number of dwarf signals as protection for the points when shunting. As the two Djursholm tracks are relatively long it has been possible with advantage to divide them by an intermediate signal on each track, enabling the succession of trains both in and out to be made closer. This arrangement is only a logical consequence of the automatic line blocking existing for 15 years, which allows of a train density of app. one train a minute.

Signal *A1* has been made semi-automatic, *i. e.*, in addition to being operated when necessary from the interlocking machine it changes automatically to danger when it is passed by trains but returns to clear when the train leaves the block circuit covered by the signal. In addition the signal shows green flashing light when signal *B* is at danger. It can thus for this train route be made to function in the same manner as an automatic block signal. The entrance signal *C* and the exit signal *E* northwards to and from the Djursholm train platforms function in similar manner.

For transshipping between the Roslagsbanan railway and the State Railways there is a track connection between Stockholm E and the State Railway station Stockholm N. This track crosses the Roslagsbanan railway goods train route after which it is divided in the goods yard into three tracks one of which is built as a three-rail track.

On the comparatively few occasions when train movements take place on these goods train routes the signals and locking are operated from a local interlocking machine, Fig. 3 and 4, set up in the immediate vicinity of the crossing between the State Railways and the Roslagsbanan railway tracks. The local interlocking machine is of the same type as the main interlocking machine but of simpler construction. Thus there is no illuminated track diagram but the control lamps and miniature signals to be found on it are instead

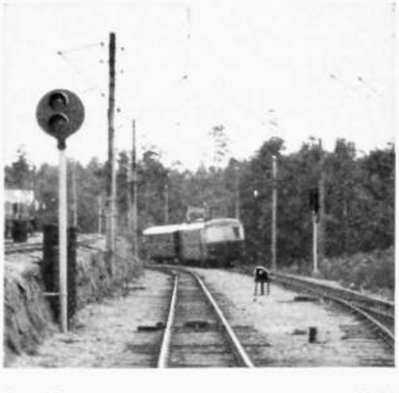


Fig. 5 X 4162
Exit northwards from Stockholm E
left, entrance signal H to first block section; middle, between tracks, rear view of dwarf signal; further to the right, entrance signal A ½

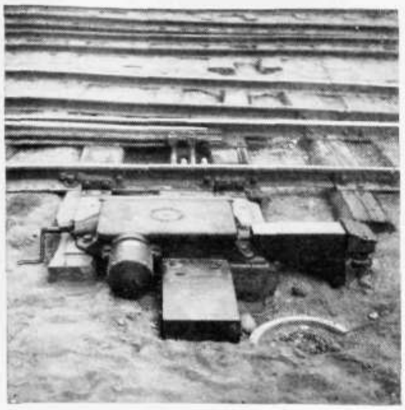


Fig. 6 X 4151
Electric point machine

grouped on the control board in a manner easily visible. The track circuits in this section can, like the home signals, therefore be controlled both from the local and the main interlocking machine. The local interlocking machine is concerned with only three points switched centrally that are also combined in the train routes for passenger trains. These points are always switched from the main interlocking machine, after which when the train route to or from the goods yard lies clear permission is given to the local switchgear to operate the signals concerned whereby the train route is locked. The train routes to and from the State Railways group of tracks do not touch the passenger train routes but all the same permission from the main interlocking machine is required for these train routes. Consequently the train dispatcher has control here also over train movements and signal positions.

The entrance signals from State Railways trains have been constructed as ordinary illuminated signals while the exit signals for both State Railway and Roslagsbanan railway goods tracks have been made for practical reasons as dwarf signals with four light apertures.

In order to be able without difficulty with single track operation to take in the trains, a special dwarf signal for the up-track, Fig. 5, has been arranged which can be set at caution and danger from the main interlocking machine. When the signal is set at caution all signals enemy to this are simultaneously blocked.

From Stockholm E there has for long been, as stated above, an automatic block system for the line northwards. The entrance to the first block section after Stockholm E is signal *H*, Fig. 5. This signal is controlled by the train dispatcher to the extent that he can set it at »danger», but not always to »clear». On the other hand he can set it so that it acts as automatic block signal. In this way therefore the automatic block signal system and the relay interlocking machine have been linked up.

Signalbolaget has supplied for this interlocking plant a new electric point machine, Fig. 6 and 7, which differs in essential parts from its predecessors. As the point machine can be laid between two sleepers the normal distance apart, thus requiring only two straight iron plates for fixing the machine to the point plate, the foundation bedding has been considerably simplified. The fully enclosed motor is fixed on the outside of the point machine. The power is transmitted to the drawbars by an angle gear. For moving the points in case of failure of current or other faults there is used a crank, Fig. 6, by means of which switching is completed with 11 turns only as against about 50 previously. Moreover, as may be seen by Fig. 7, the box holds the necessary contacts etc. for relay current circuits, supervisory current etc. The motor's power is 0.5 hp. The whole point machine weighs only 180 kg, *i. e.*, 40% less than the older type.

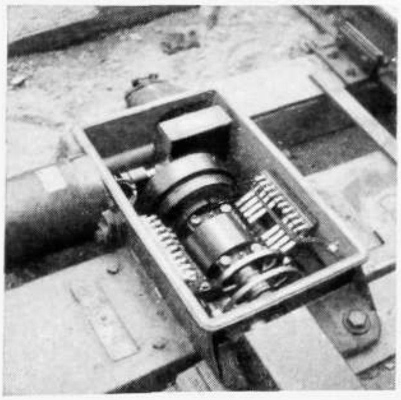


Fig. 7 X 4152
Electric point machine
with cover removed

To accomodate the interlocking control machine and the train dispatcher a small extension to the station building has been added, on the wall of which the illuminated track diagram has been set up. At a convenient distance from this a desk for the train dispatcher is placed with the control board mounted on the back edge, Fig. 2. The whole of the left wall consists of a window with a clear view over the platforms. On one wall there is a wholly enclosed electric plant, fed from the station main supply with 220 V A.C., 50 c/s. From this plant the current is distributed to group plants for the interlocking machine and station illumination. In this office there is a main switch by means of which all lights on the station can be extinguished. Further fuses for the interlocking machine are grouped in a relay room for all relay current circuits and in a cupboard of the desk for all motor current circuits. These last consist of automatic fuses by means of which if a fuse blows in a motor current circuit the train dispatcher can rapidly and easily re-connect the current without needing to call in signal repairers.

The relay compartment is in the cellar beneath the interlocking machine room. In this way it has been possible to draw the wires in a convenient and simple manner through the beams. In addition to five lighting and telephone cables there lead out from the interlocking machine 15 signal cables, with altogether about 400 wires. Of these, 10 are main cables which lead to as many distribution boxes and apparatus cabinets to which signals, track transformers, locking devices, point machines and so on are connected by local cables. In the relay compartment and the apparatus cabinets all multi-wire cables have been terminated in boxes, so that the wires should be most easily accessible for test and repair.

The work of fitting, which was done by the staff of the Roslagsbanan Railway with the assistance of a fitter from Signalbolaget, was begun in the summer of 1940 and has just been completed. The cost of the plant amounts to some 130000 kronor.

In addition to the advantages stated there is the further gain with the electric interlocking machine that the staff previously required is set free for other work, which means a decrease of operating costs by about 13000 kronor per year. Apart from the fact that the old interlocking machine would not have been capable of dealing with present traffic without thorough-going reconstruction the saving referred to constitutes satisfactory interest on the capital expended.

Laboratory Terminal Blocks

H BLOMBERG & J WIKSTRÖM, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

U.D.C. 621.317.2

In conjunction with the fitting up of laboratories and test-rooms in L M Ericsson's office and factory building at Midsommarkransen, Stockholm, the need arose for up-to-date connection panels for the connection and distribution of current required for laboratory and working benches. As suitable arrangements were not to be had on the market and as the numbers required were large, the problem was tackled of producing special designs for the purpose. The result has been a connection unit, the laboratory terminal block, by means of which connection panels of different types and for various requirements may be built up. These should certainly find great employment in laboratories, test-rooms etc. in factories, schools and higher educational establishments, and have consequently been made available for sale.

The types of electric connection panels for connection and distribution of current to benches in electrical laboratories, test-rooms and workshops hitherto employed can hardly be said to meet modern demands on such equipment. They have as a rule, consisted of panels of marble, insulation material or sheet-metal, drilled appropriately for the fixing of the necessary switches, fuses, terminal clamps etc. The switches have consisted of ordinary knife-edge switches, when great current intensity was concerned, or of box switches of the various types on the market. In the former case the parts under tension were not protected against touching. Such panels had to be designed for each occasion and there were no standard types available. In place of these panels, there had also been used the castiron enclosed installation material that is really intended for outdoor service or special premises, a number of these being set up alongside each other on walls or racks. In this way the equipment has been less appropriate from the point of view of work and besides it was expensive and clumsy.

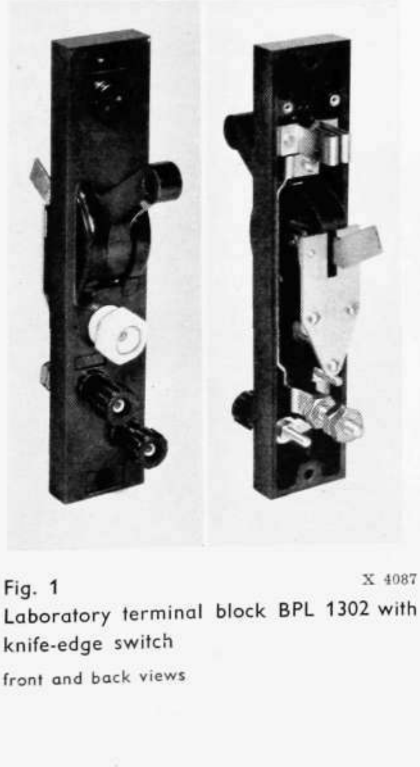


Fig. 1 X 4087

Laboratory terminal block BPL 1302 with knife-edge switch

front and back views

General Execution

By means of LM Ericsson's *laboratory terminal block* it is now possible to build up connection panels in any combinations according to the purposes to be provided for. It consists of a terminal block, to be had in a number of variants, comprising the basic element of which the connection panels are made up. In this way the panels are such that they can easily be altered or extended should need arise.

The block is made of bakelite with the live parts protected against touch, it is of small convenient size and easy to fix on the frame or other fitting constituting the support. At present it is available in the form of a block containing knife-edge switch, fuse and terminal clamps, a block containing terminal clamps and fuses, a block containing terminal clamps only and finally a block which is either unfitted and then is used to fill up free space in the connection panel or fitted with any desired device such as wall tapping, special connection jacks or the like.

All blocks consist of a moulded rectangular base of electro-brown bakelite, 50 mm wide and 250 mm long, on which the connection devices are arranged. At each end of the base there is a hole for fixing it on the frame on which the blocks are fitted close together. On the front of the blocks there are rec-

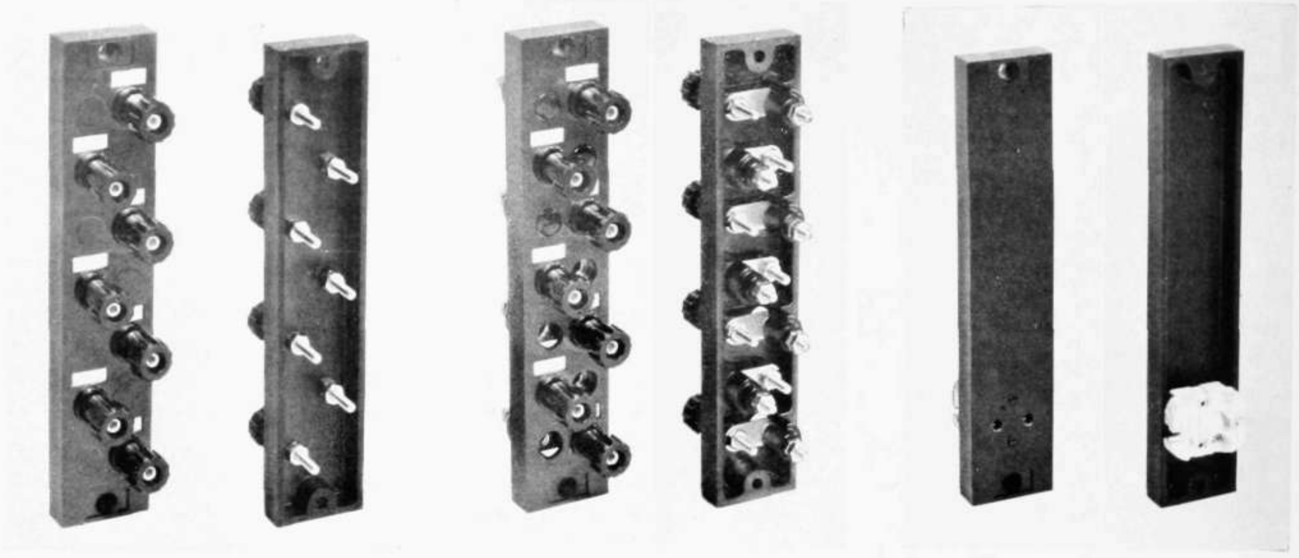


Fig. 2 X 4089 X 4088 X 4090

Laboratory blocks

left, BPL 1207 with terminal clamps and fuses; middle, BPL 1107 with terminal clamps only; right, BPL 1000 fill-up block fitted with a wall tapping

tangular recesses intended to hold label frames, in which are fitted a strip of thick paper protected by a cellon sheet. The paper is used for labelling the block. Corresponding label recesses are to be found beside all terminal clamps, Fig. 2.

Block with Knife-edge Switch and Terminal Clamps

The knife-edge switch terminal block BPL 1302, Fig. 1, has connection bolt, knife-edge switch, fuse and two terminal clamps. The connecting bolt for the incoming line is located at the bottom of the back of the block. It is connected with the fixed contact springs of the knife-edge switch by a connecting bar. The knife-edge switch, which is single-pole, is also located on the rear of the block, but the switch lever projects from the front through a slot in the block. This lever is of bakelite and the knife itself is cast into it. It actuates contact springs which are supported by a bar at the bottom, which also constitutes the bottom contact in the fuse arranged below the knife-edge switch. The switch is made without momentary break and with 250 V D.C. can break 25 A and, with 500 V A.C., it breaks 50 A non-inductive load. To maintain centring of the knife in off-position, for which the lever points upwards, the lever is centred in this position by drag-springs fitted at the back.

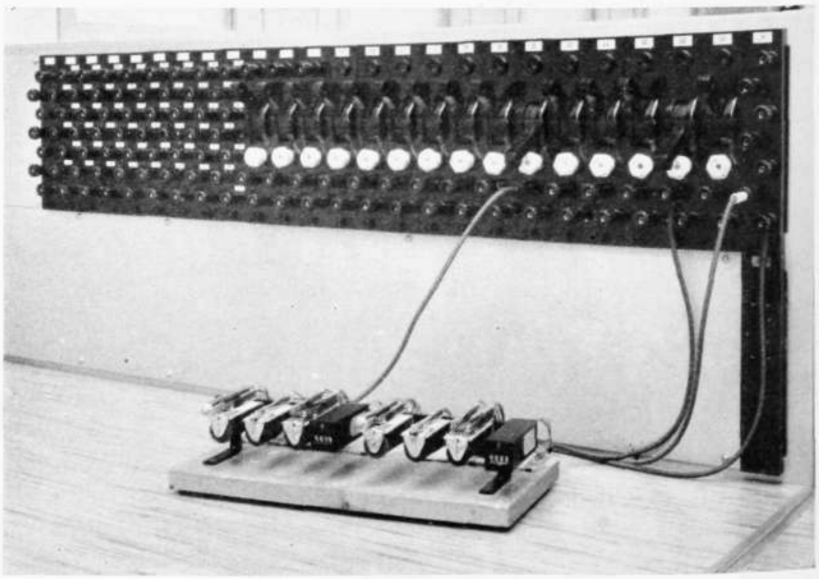


Fig. 3 X 5781

Connection panel for laboratory bench

with blocks fitted in one row

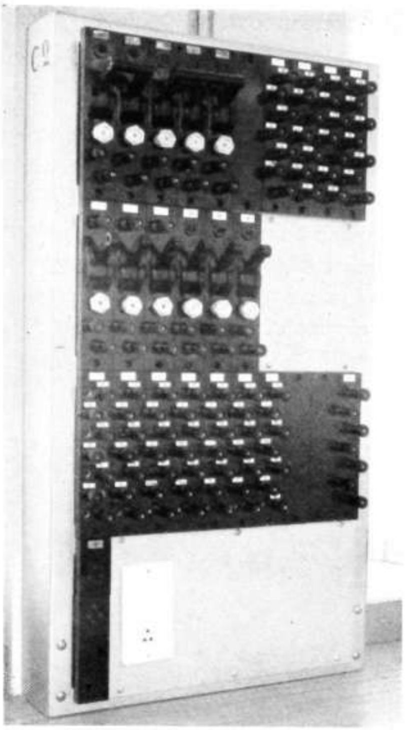


Fig. 4 X 4091
Connection panel
with blocks fitted in several rows

The fuse is of standardized construction with fuse head of porcelain having Edison thread E 16, which sticks out at the front of the block. The fuse is of standard type for current intensity between 2 and 25 A. When the switch lever in on-position is down it covers the fuse to a certain extent, so that the switch must be at break to enable the fuse to be replaced.

Below the fuse and connected to its contact sleeve, there are arranged two terminal clamps connected in parallel for connection of the apparatus or apparatuses that are to be tested etc. The clamps are made as pole screws with bakelite nuts having threaded sleeve cast on. The connection of the lines may be done either with cable shoes beneath the nut or with banana contact in the centre contact sleeve of the nut or both ways at the same time. Thus it is possible at one time to connect four tapping lines entirely independent of each other to the block.

As may be seen, all live parts are arranged at the rear of the block and are therefore entirely protected against touch when the block is fitted on the frame of the connection panel. The block is of very simple construction, with parts few and strong, and with no extra circuits, so that the number of contact transition places is brought down to a minimum.

The block is made only with single pole switch. To obtain two, three or multi-pole switches, two, three or more such blocks are fitted side by side. The switch levers are joined by one or more cylindrical connection links of bakelite, which are fitted in holes at the ends of the levers by means of screws and bolts, see Fig. 1.

The block may be provided with spark quench at the knife breaking point if required. In addition a signal lamp, either neon or filament lamp, may be fitted in the circular projection of the bakelite above the switch lever by inserting a special lamp holder.

In certain cases it is desirable, instead of terminating the incoming line permanently to the bolt at the rear of the block, to be able to give it a moveable connection to the block. For this purpose there is a variant, BPL 1303, which is fitted with an extra terminal clamp at the front of the block above the switch lever and joined to be fixed contact springs of the knife.

Blocks with Terminal Clamps

The laboratory terminal block BPL 1207, Fig. 2, comprises seven terminal clamps each with its own fuse. The clamps are pole screws of the same type as for the knife-edge switch block. The fuses are arranged at right and left of the clamp screws. The fuse heads, which are of bakelite, are recessed in holes at the front of the block and have a slot for screwing in and out with a screwdriver or the like. Fuses are available for currents between 0.7 and

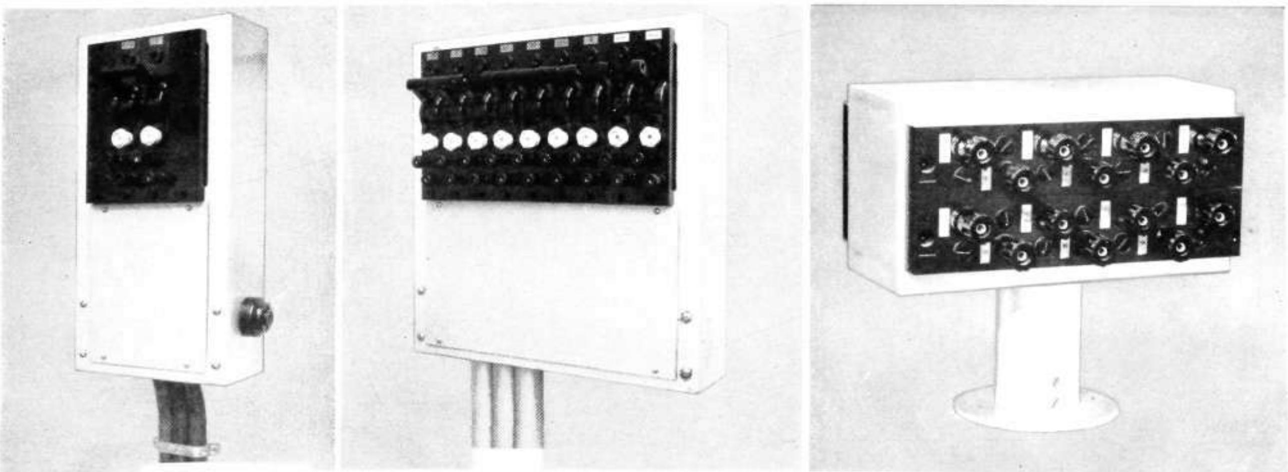


Fig. 5 X 7240
Smaller connection panels
left, with two-pole switch fitted on the wall; middle, with one, two and four pole switches, fitted on the wall; right, with terminal clamps and fuses, facing two ways on workshop bench

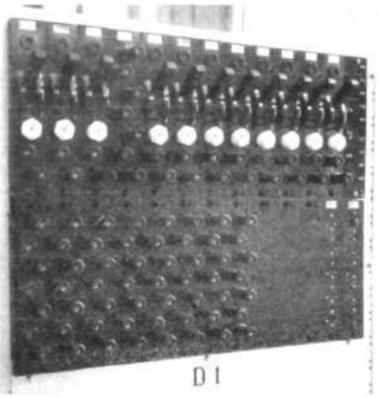


Fig. 6 X 4092
Connection panel
with knife-edge switch terminal blocks and additional terminal clamps

6 A. The incoming line is terminated in the bottom contact of the fuse, while the threaded sleeve in which the fuse head is screwed consists of a terminal strip joined on to the pole screw.

The laboratory terminal block BPL 1107, Fig. 2, which only contains seven terminal clamps, is intended partly for distribution of connection lines which do not carry current, *e. g.*, measurement lines, or lines that are not to be protected, and partly as supplement to the switch terminal block when its two terminal clamps are not sufficient for the number of tapping lines it is required to connect. In the latter case it is fitted below or alongside the switch terminal block and its clamps are connected with the clamps of the said block.

The laboratory terminal block BPL 1000, Fig. 2, consists only of the flat bakelite base with its fixing holes. In this form, *i. e.*, entirely without fittings, it is used as fill-up block in the connection panels and is put into the free spaces of the panel where it may later be desired to put in terminal strips. The block is particularly well suited, however, for the fitting of special devices not to be found on the standard blocks. For example, the figure shows the block fitted with the inset of an ordinary wall tapping for 220 V tension.

Connection Panels

The laboratory terminal blocks are fitted alongside and beneath each other in frames or racks of suitable design. Particularly to be recommended is the making of these from 2—2.5 mm bent sheet metal of design similar to that of the racks in LM Ericsson's automatic telephone switchboards on the XY-system. Fig. 3—7 show a number of such connection panels which are employed in the new laboratories and workshops.

The frames are welded throughout of ⊏ bent sheet-iron with 120 mm body and 40 mm flanges. The flanges are drilled with holes at 50 mm intervals, for screwing in the fixing screws of the terminal blocks. The frame encloses the blocks from the sides completely, at the same time serving as protection and support for the incoming lines. The rear of the frame and those parts of the front not taken up by terminal blocks are filled up by suitable cover plates. In this way there is obtained a connection panel well protected against dust and mechanical stress which is moreover inexpensive and easy to mount on floor, bench or wall.

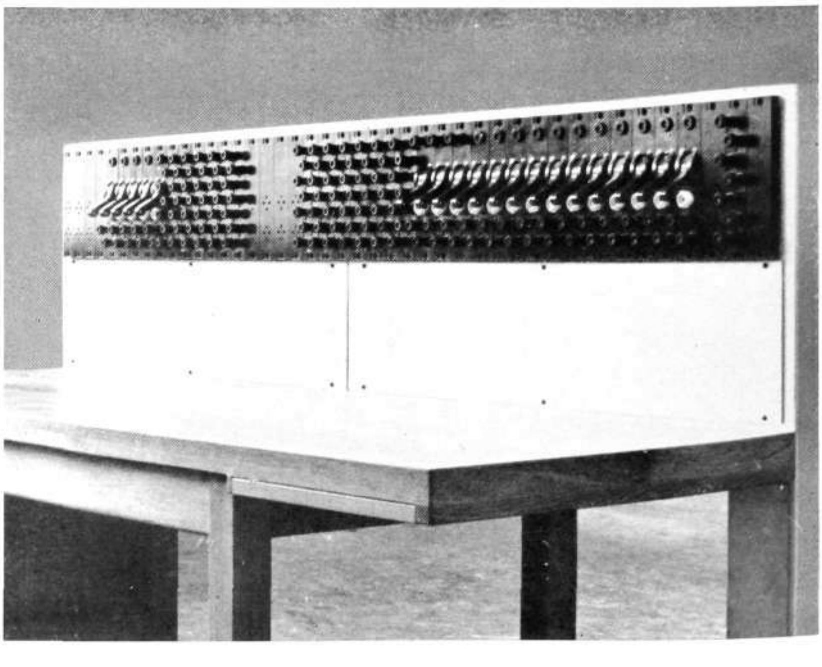


Fig. 7 X 5786
Connection panel
fitted in floor rack along laboratory bench

U.D.C. 621.395.44

Bohlin, T: *Three-Channel Carrier Telephone System for Open-Wire Lines* Ericsson Rev. *23* (1946) No. 1 a pp. 50—70

The three-channel system is the classic solution of the problem of high grade carrier telephone communication over long distances. Growing demands as well as steady improvements of both electron valves and other elements used in carrier technics, however, justified a thorough revision of the three-channel system. The new system built by LM Ericsson and completed in 1939 is of entirely new design. Installations with this new systems have now been in satisfactory use during several years at different places. A description in detail of the system is given in the article.

U.D.C. 621.395.64

Ljungberg, I: *Rural Line Repeater with Negative Feed-back.* Ericsson Rev. *23* (1946) No. 1 a pp. 71—74

For lines, which are long but not long enough or with so many circuits that a normal repeater station is warranted a small repeater equipment, consisting of 2-wire repeaters, is often useful to compensate part of the line attenuation. The rural line repeater ZMK 5001, described in the article, is designed to meet the above demand and is an improvement on LM Ericsson's rural line repeater of older construction. The line repeater has smaller dimensions in its present construction.

U.D.C. 621.395.64

Ljungberg, J: *New Ringing Repeater.* Ericsson Rev. *23* (1946) No. 1 a pp. 75—77

With the ringing repeater types earlier used for two-and four-wire circuits with 15—50 c/s signalling current, the outgoing signal from the ringing repeaters is shorter than the incoming and furthermore the signal is delayed a comparatively long time owing to the inertia of attraction which is necessary in repeaters of older design. This has caused the inconvenience that, as regards long lines needing several ringing repeaters one after the other, the length of the ringing signal is reduced in each ringing repeater. Thus the original signal must have a length exceeding the total of these reductions.

In the article a ringing repeater is described, where the output signal has the same length as the incoming one and where the operation time has been reduced to less than a third of that for ringing repeaters of older type.

U.D.C. 656.257

Insulander, H: *New Press-Button Interlocking Control Machine* Ericsson Rev. *23* (1946) No. 1 a pp. 78—80

In conjunction with the ordering by the Swedish State Railways of twenty-five press-button interlocking control machines, Signalbolaget put in hand a re-designing of the press-button interlocking control machines as formerly manufactured. The construction of press-button interlocking control machines, thus arrived at, which displays a number of essential improvements in respect of facility for alterations and enlargements, is described in the article.

U.D.C. 656.05

Forchhammer, N: *Street Traffic Signal Plant with Impulse Coils.* Ericsson Rev. *23* (1946) No. 1 a pp. 81—84

For many years Dansk Signal Industri A/S, Copenhagen, in collaboration with LM Ericsson's Signalaktiebolag, Stockholm, has been working on street traffic signal plants. In 1933, the company executed the plant at Fredriksberg, which aimed att the best possible adaptation to the traffic by making the different signals dependent on each other by synchronizing. In recent years a different principle has been introduced, whereby the signals are wholly or partially operated by the vehicles themselves.

The first signal constructed by Dansk Signal Industri for vehicle operation is specially designed for such conditions, as it is a type particularly suited for employment where a main street with heavy traffic is intersected by a street with traffic which, though small, is appreciable — at least at certain times of the day.

U.D.C. 656.216.2+656.25

Lundberg, T: *Interlocking Plant at the Bascule Bridge over the Falsterbo Canal*. Ericsson Rev. *23* (1946) No. 1 a pp. 85—87

In conjunction with the construction of the Falsterbo Canal and the bridge over the canal for railway and highway traffic to Falsterbo there was arranged an interlocking plant. The plant was ordered by Mr. Rudolf Kolm, chief of the bridge building section of the Highways and Waterways Board, from Signalbolaget and was put into service in April 1941. The interlocking machine comprised in the plant is a relay interlocking machine (or press-button interlocking machine).

U.D.C. 656.257 (487.1)

Montell, H: *Centralized Traffic Control on the Stockholm—Saltsjöbaden Railway*. Ericsson Rev. *23* (1946) No. 1 a pp. 88—93

In recent years systems of the kind described in the article have found increased employment abroad, especially in USA. In Sweden a plant of this type was delivered in 1938 by LM Ericssons Signalaktiebolag to the Stockholm—Saltsjöbaden Railway. The plant which has now been in service for 6 years with good results was developed in consultation and under the supervision of Mr. T. Hård, departmental chief in the Royal Swedish Board of Railways. The account was published in Nordisk Järnbanetidskrift, with whose kind permission it is reproduced.

U.D.C. 656.257 (487.1)

Kullenberg, S: *New Interlocking Plant at Stockholm East Station*. Ericsson Rev. *23* (1946) No. 1 a pp. 94—98

The Stockholm—Roslagens Railways have for some years had a number of realy interlocking control machines (with press-buttons) in operation. As the traffic at the biggest station of this railway system, Stockholm East, had grown to such an extent that a complete reorganization of the whole station has become necessary and with it a new signal intelocking plant had to be constructed, the administration decided to equip the station with a relay interlocking control machine of Signalbolaget's manufacture. That this choice was made is due largely to the good experience obtained from earlier plants.

U.D.C. 621.317.2

Blomberg, H & Wikström, J: *Laboratory Terminal Blocks*. Ericsson Rev. *23* (1946) No. 1 a pp. 99—102

In conjunction with the fitting up of laboratories and test-rooms in LM Ericsson's office and factory building at Midsommarkransen, Stockholm, the need arose for up-to-date connection panels fort the connection and distribution of current required for laboratory and working benches. As suitable arrangements were not to be had on the market and as the numbers required were large, the problem was tackled of producing special designs for the purpose. The result has been a connection unit, the laboratory terminal block, by means of which connection panels of different types and for various requirements may be built up. These should certainly find great employment in laboratories, test-rooms etc. in factories, schools and higher educational establishments, and have consequently been made available for sale.

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Lars Magnus Ericsson —

a Brief Biographical Sketch

HEMMING JOHANSSON, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

U.D.C. 92 Ericsson LM

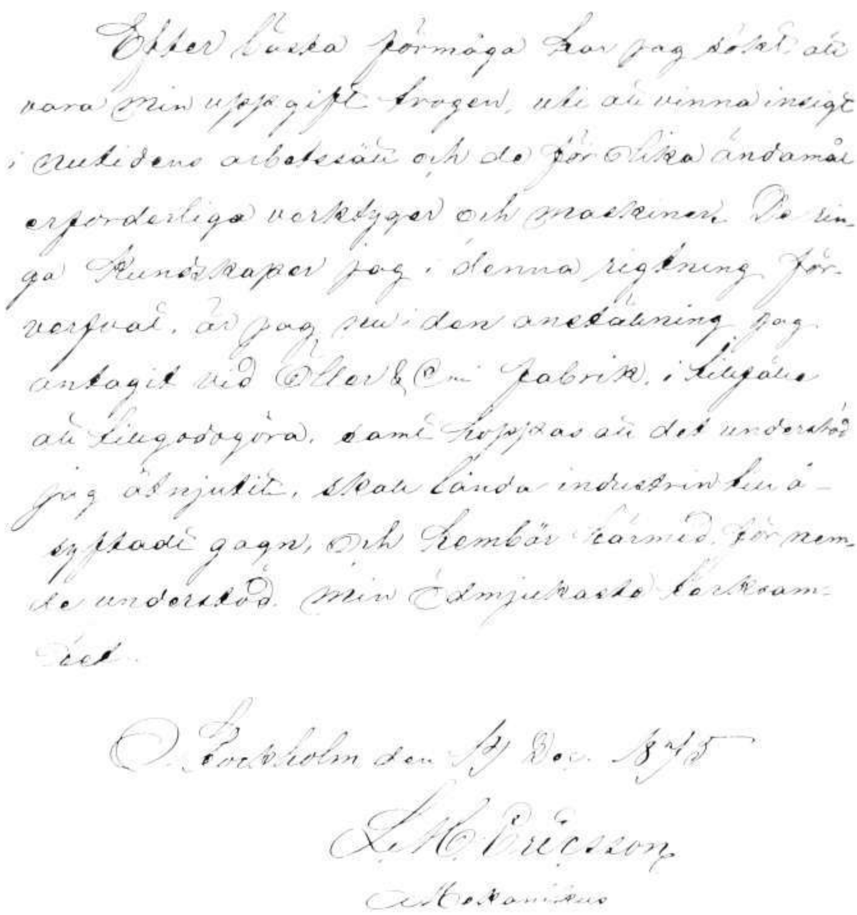
»The undersigned, who during his stay abroad has been in receipt of one of the State grants, begs to furnish herewith a brief report on the 2½ years spent at different factories in Germany and Switzerland.

In Berlin my first engagement was at Siemens & Halske's factory, where in the course of 11 months, by working in different departments I was able to acquire knowledge both of the methods of working and of the different telegraph instruments manufactured there.

I also worked in Berlin at Lud. Loewe & Co's factory, where I was able to learn something of the advantages of the American machine-tools. Moreover at Kernaull's scrap metal factory, where I also worked, I found much that had hitherto been unknown to me and which was of interest to observe, as was the case at A Ronsack's workshops for mathematical instruments, such as theodolite level instruments etc., and there too was produced a new kind of sight control instrument of simple construction, designed by a certain Captain Mieg and employed by the Prussian Army. The instrument consists of a sight and a bead, the appearance of which may be seen on attached sketch. It is fitted on the rifle parallel with its line of aim, but in such a way that the shooter may without interference at the same time sight an object, while a person standing at the side to the right, by means of reflection from a mirror fitted behind the sight, can with the naked eye obtain a picture of the bead sighted and the object at which the rifle is aimed. Fig. A shows in natural size two vertical projections and Fig. B horizontal projection of the sight with mirror and its setting. How the sighting instrument is fitted to the rifle by means of a strap and with cordon screws united to the upper part should be easy to understand without further description. The bead, Fig. C, lies sufficiently steady by being made fast at the end of the barrel.

Moreover I have worked in Munich at the physics institution of Prof. Dr. Ph. Carl, and in Berne with the firm of Hasler & Escher, where I was employed on the assembly and adjustment of self-recording thermo-hygrometers, designed by Prof. Wild. In Neuchatel, Strasburg and Karlsruhe I have either been employed at or visited the best-known works.

Latterly I have had employment at Schäffer & Buddenberg's factory in Buckau Magdeburg, where my chief work was the assembly and adjustment of indicators, but I was able also to devote attention to the distribution of work, machine-tools and plant for special purposes, being able to discover, for instance, that the bent tube in Bourdon's gauges could be made for less than half their cost at home in labour alone. The difference in manufacture consisted essentially in that, instead of filling the tube with pitch and then bending it between two rolls, it was filled at Buckau Magdeburg with fine sand and then bent round *one* roll, for which a multi-service lathe is well adapted, as between the points the large roll in which a groove is turned along half the elliptical section of the tube is rotated and the smaller pressure roll, which likewise has a corresponding groove, is fitted on the support. It is then only a question of fixing one end of the tube in the groove of the large roll, after which it is allowed slowly to rotate a couple of turns, during which the tube is bent to the desired shape.



Efter bästa förmåga har jag sökt att vara min uppgift trogen, uti att vinna insigt i nutidens arbetssätt och de för olika ändamål erforderliga verktyger och maskiner. De ringa kunskaper jag i denna riktning förvärfvat, är jag nu i den anställning jag antagit vid Öller & C:s fabrik i tillfälle att tillgodogöra, samt hoppas att det understöd jag åtnjutit, skall lända industrien till åsyftadt gagn, och hembär härmed för nämnde understöd min ödmjukaste tacksamhet.

Stockholm den 14 Dec. 1875

L. M. Ericsson

Mekanikus

X 6190

Facsimile of Lars Magnus Ericsson's report on his travels

To the best of my ability I have tried to carry out my mission faithfully, by obtaining an insight into present-day methods of working and into the tools and machines requisite for this purpose. The modest knowledge I have been able to acquire I have now occasion to make use of in the position I have taken in Öller & Co's factory and I trust that the grant I have enjoyed will prove to the anticipated advantage of the country's industry and I hereby express my humble thanks for the said grant.

Stockholm, 14th Dec. 1875

L. M. Ericsson

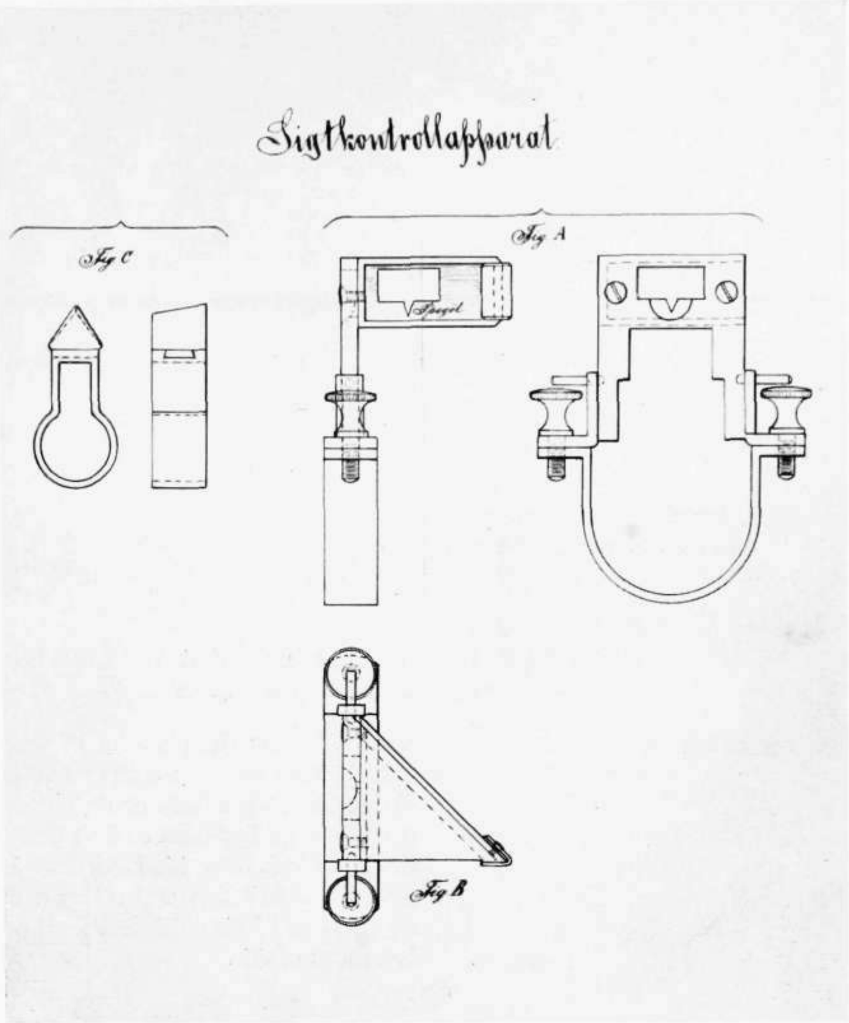
Mechanical engineer.»

Thus read the report Lars Magnus Ericsson gave of his studies abroad, undertaken with the support of two state grants. It is by no means lengthy and verbose. Yet rarely has hope expressed in thanks for grant enjoyed, that this might be to the anticipated benefit of the country's industry, been fulfilled to such high degree as in this case.

With those foreign studies Ericsson had completed the work of his training. On 1st April 1876 he started in independent business. The employment with Öller & Co. referred to was not of long duration, therefore.

In the phase he was now leaving behind him he had had abundant proof the serious side of life in the form of privations, grief and toil, but he had also acquired experience and knowledge of inestimable value for his future activities.

Like many other capable men who have worked up undertakings from modest beginnings to greatness and who have been privileged to make considerable contributions to developments, Lars Magnus Ericsson grew up in modest not to say poor circumstances. He was cradled in a small farm Nordtomta, owned by his father, Erik Ericsson, in the village of Wegerbol in Värmskog



X 6191

Sight control instrument

Sketch of sight control instrument, attached to Lars Magnus Ericsson's report

Parish. There the engineer and great industrial magnate first saw the light on 5th May 1846.

In the late years of his life, when about 66 years old, Ericsson gave in a letter to one of his sons some particulars of the first 20 years of his life. It may be permitted to give some extracts from this simple though expressive document. Those who knew Ericsson's moderation of expression, his modesty and lack of pretension, will understand that behind the words quoted there lies very much more of self-denial, trouble and toil than is expressed by them.

»The first eleven years of my life were spent under the protection of a god-fearing and respected father, but with his sudden death came the first serious blow. There were left at home my mother, myself and two younger sisters; two elder brothers had already set out to earn a living. In those days there was not yet any regular school attendance and I was free to follow my bent for handicraft and general childish ponderings, intermixed with mischievousness and boyish tricks, which were common in those days as at present. Time passed in that way until my 14th year when, on condition that I was sure in repeating by heart, I was permitted to 'take lessons from the parson' one year earlier than was usual.»

According to reliable sources the lad had in 1853 reached the second class of the Wegerbol school and five years later he was in the seventh class of the Björnebol school. The education he received at school, however, was exceedingly inadequate; he had his thirst for knowledge and his good head to

X 6151

Nordtomta, Lars Magnus Ericsson's early home in the parish of Värmskog, Värmland province

thank for the foundation on which he was later by persistent independent study to build up his by no means inconsiderable knowledge.

After attaining the maturity of confirmation, Lars Magnus had to devote himself more seriously than had hitherto been possible to the maintenance of the home. He got work as day labourer at a farm in the neighbourhood for a wage of 50 öre (about 6d in those days) per day, but he soon found that he lacked both disposition and strength for that kind of work. In his younger days his constitution was rather weak, which was certainly a result of the deprivations of his childhood. Exemption from the obligations of conscription is witness of this.

The following statement would seem to indicate that the peace of mind of this 14 year old was not free from disturbance: »Such was the course of my 14th year, spiritually rich, which directed my thoughts to the serious things of life and fortified my determination honestly and trusting in God to meet future destiny.»

He goes on: »As I was entering my 15th year there happened for me a fortunate circumstance, a mine overseer — who had been a good friend of my father — was given the mission of going to Norway with some experienced miners to investigate the value of ore deposits acquired in the region of Egersund. Though I was so young, my persistent pleas enabled me to join the troop and my first job was to carry drills from the smithy to the blasting places, and in between to help at the forge.

When we had been there about ½ a year, it happened that the smith got a yearning for the town and stayed there longer than he should have done. While he was away I carried on with the drills and all were so satisfied with their sharpness that the result for me was that shortly after I was entrusted with the work of the smithy. This led to improvement in my pay, so that I was able to send quite appreciable amounts to those at home who were existing there in poverty, being able to earn nothing.»

Between the lines one can read that Lars Magnus had already gained a skill remarkable for his 15 years in that special domain. The 66 year old man would not directly admit it; that was quite contrary to one of the characteristic features of his being, modesty.

When after a couple of years it was found that working of the deposits could not be made to pay, Ericsson received a similar job, as leader of a labour gang to »investigate an ore-bearing seam that had been acquired in the primitive forests in the neighbourhood of the township of Gösse». After having ascertained that this too was valueless, Ericsson was given work for a time on the north-western main railway line then under construction.

His thoughts and wishes, however, were turned in quite another direction. »Deep down, however, there smouldered an ever stronger desire to learn a trade, preferably in the mechanical branch and I heard of two art-metal smiths in the neighbourhood. One was Hult in Grafås and the other was Nils Andersson in Heljeboda. As by then I had put aside a little for my own needs I made up my mind to seek a place as apprentice and with this object went to Hult, with whom I was allowed to stay; but as the man was aged and moreover in poor health, so that he was seldom able to be in the smithy, both he and I decided it was useless for me to stay any length of time and through Hult's good office I went to N. Andersson in Heljeboda, getting quite a good impression at the beginning. The smithy was arranged for waterpower and there for the first time I saw a slide lathe. Soon, however, deception set in for the master smith himself was most of the time travelling and rarely in the smithy, so that one of his younger sons and I had mostly to carry on by ourselves. It soon became apparent that financial troubles were the cause of Andersson having to leave everything and he then moved to Charlottenberg Works as head of the nail-making department, which even in those days was carried on with special machines. In his contract with the Works he had stipulated that he should take me along as apprentice.»

Ericsson seems to have been satisfied with his work at the Charlottenberg Works, where as he says himself he had »a great deal to learn», but the yearning of this eighteen-year old for a field of activity offering greater prospects of development left him no peace. One after another he worked at smithies in Arvika and Karlstad. What he learned there does not transpire from his account but merely that he had to »work like a dog»: »During those years of learning I received no more than the minimum of food and rest in a dirty smithy room. Anything else I had to get as best I could and I took up the engraving of seals in my leisure time, for which there was a gratifying demand.» Here we get a glimpse of his mettle; the smithy apprentice is handling not only the sledge-hammer but also such a fine tool as the graver and, as can be divined from the modest words, with success. He saved up a little capital and this put him in a position to take a long step towards the realisation of his dreams. He journeyed to Stockholm and there, he writes: »led by a kind providence I found a place at Öller & Co's Telegraph Factory and, after one week's trial, received wages sufficient for my needs, so that I most thankfully saw life much brighter than ever before and felt then the first breath of the joy of life in my heart.» — Certainly it would not be the wage, sufficient for his needs, of 5 kronor per week that awakened that first breath of joy of life in that lad of 20, but more probably the definite feeling that he had come into a field of labour where his ability and still dormant force could make themselves fully evident.

This epoch markes the end of Ericsson's own notes.

The first seed of electro-industry in Sweden was sown in 1857 when the director of telegraphs A. H. Öller set up a workshop for the manufacture of electro-technical articles, particularly telegraph instruments and other material for telegraph stations. However, this embryo displayed no great ingrained vitality; consequently the telegraph administration found reason to intervene and arranged for the grant from state funds of 1.200 kr. for each of the years 1861—63. Öller's workshop was entirely on a handicraft basis; nevertheless it constituted a school for the training of skilled workmen in the making of electro-technical instruments. The best known of these was to be Lars Magnus Ericsson.

Ericsson served Öllers for six years and acquired the reputation of a particularly industrious and skilful instrument maker. In order still further to perfect himself in his trade by studies abroad he applied for state travelling scholarships; twice these were awarded to him on Öller's recommendation, for the years 1873 and 1875.

His six years in Stockholm had been well utilised, even apart from the regular working hours at Öller's. By study in his spare time — especially in draftmanship and languages — he had both laid a solid rational foundation for his inborn constructive bent and gained a knowledge of languages not to be despised, chiefly in German but also in English, which no doubt to some degree contributed to the granting of the travelling scholarships.

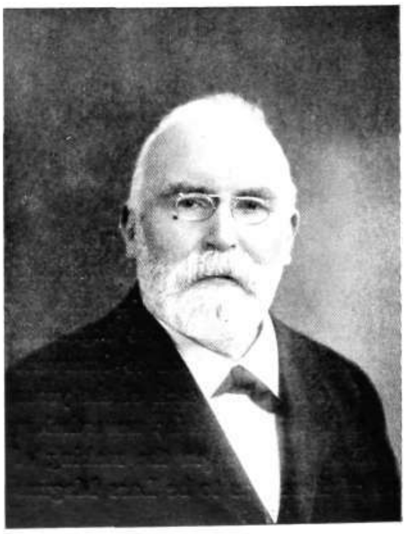
His workshop studies abroad were carried on in a manner which he himself considered ensured the greatest benefit but which perhaps was not entirely to the liking of his various employers. He took employment at one workshop after he other; after having at one place by using his eyes and straining his attention observed everything that he considered of value for his object and moreover having strengthened his travelling resources by the wages earned he would leave that place and go on to the next.

X 4425

Lars Magnus Ericsson
at the age of 25

Following his return to Stockholm, Ericsson decided to realize an idea which had probably long been in his mind; his great caution would not have permitted him to set a plan in operation before it had been subjected to thorough and detailed examination. Be that as it may — on 1st April 1876 he opened, as already stated, his own electro-mechanical workshop in the building No. 15 Drottninggatan in Stockholm. The beginning of a business in more modest circumstances can hardly be imagined. »The workshop» was housed in a kitchen he rented. »The staff» consisted of Ericsson himself and a 12 year old office boy. »The machinery» was represented by an instrumentmaker's pedal lathe. »The working capital» amounted to 1 000 kr. and had been obtained on loan from one of Ericsson's acquaintances, Mrs. Maria Strömberg of Nygård, a person who seems to have been clearsighted enough to believe in a bright future for the industrious young man. But even it outwardly the new enterprise displayed the mark of the greatest unpretentiousness, the personal contribution of Ericsson was so much the more considerable. Enormous capacity for work, tough energy, remarkable skill in the trade and extensive experience in the domain he had made his own combined with honesty and prudence in business matters were the foundation stones on which Ericsson could base his activity. The expansion up to that day in May 1903 when the man now 57 years old passed over to other hands his undertaking that had been worked up to a world industry constitutes indisputable evidence of the solidity of the foundation.

Shortly after starting Ericsson took in as partner Carl Johan Andersson, four years younger than himself, who had been a workmate of his at Öller's and likewise had studied abroad with the help of scholarships. Andersson put 1.000 kr. in the business, which now received the name of L.M. Ericsson & Co. Under that name work continued until 1896 when Ericsson, who in the course of time had taken over sole control with Andersson as works manager, turned over the business to Aktiebolaget L.M. Ericsson & Co. (L. M. Ericsson & Co. Ltd.). The share capital was put at 1 000 000 kronor and was owned in its entirety by Ericsson; in recognition of valuable collaboration, he presented Andersson and some of his other employees with a number of shares as a gift.


X 4407

Carl Johan Andersson
Ericsson's partner, portrait taken 1920

The time between 1876 and 1896 constitutes a period of intensive work and marked expansion in which Ericsson himself was ever the leader and, it is justifiable to say, the foremost worker. In the initial stages activities were devoted chiefly to the repair of telegraph and other electrical instruments, but new designs also soon appeared on Ericsson's programme of work. Among other things, on instructions from the Swedish State Railways, he designed an excellent receiver for dial telegraph instruments which at that time were

X 4424

Workshop at Oxtorget
where LM Ericsson's business was located
1877—1880

employed to a large extent on railways. Another design dating from the earlier years is a fire telegraph system for medium sized communities, a system which became wide spread not only in Sweden and which with certain modifications is applied even at the present day.

It was not long before Ericsson acquired a solid reputation for the high quality of his work and he succeeded in a short time in getting connections with administrations and institutions which had employment for instruments of the kind, such as the Telegraph Administration, the Fire Brigade, the Police Administration, state and private railways etc.; these connections have since then constantly remained.

And then one day noteworthy news reached Sweden, and this gave to Ericsson's work a direction which was to lead to unanticipated and splendid results. It was the report of Graham Bell's invention, the telephone, circulated by the newspapers and which came to Ericsson's knowledge in that way. He would seem intuitively to have perceived a great new field of work opening before him; he began to study the principle of the wonder and in a short time succeeded by experiment in producing serviceable telephones. (In the first years, before the microphone principle was devised, the telephone had to serve both as transmitter and receiver.)

From Ericsson's books we find that his first telephones for practical use were debited to the firm of Bredenberg in November 1878: »A couple of telephones with trumpet to Bredenberg Kr. 55:—.» The trumpet was intended for the giving of signals through the telephone line. Then came more deliveries in close succession. Even before then Ericsson had had telephones in for repair several times, some for the wellknown firm of Numa Pettersson. The telephone had in fact been introduced into Sweden in 1877; the first line was set up between the residence and business premises in Stockholm of H. T. Cedergren, American instruments being employed.

As long as the telephone was only used in this simple manner, *i. e.*, for private use, its spread was considerably restricted; the manufacture therefore in this period was of no great extent and was carried on entirely as a handicraft. The wages lists show the modest dimensions of the business. At the beginning of 1879 there were eight workmen, at the close of that year ten. But the following year was more lively and Ericsson, who had already found it necessary to change premises twice, now found himself obliged to move again to provide space for an ever increasing number of workmen and machines. Suitable premises were found at Biblioteksgatan 5 where the Röda Kvarn moving picture house now is. Expansion now was at a much more rapid rate; at the close of 1881 the number of workmen amounted to 30 and one year later it was 50. The business was gradually leaving the stage of craftmanship and becoming an industry.

The increased turnover was caused essentially by the conversion of the telephone from a convenience in the nature of a luxury for private use to a means of communication in the service of the public. As far as Sweden is concerned this took place in 1880 when the American Bell Co. constructed the first telephone networks in Stockholm, Gothenburg, Malmö, Sundsvall and Söderhamn, naturally employing American material. To be in a position to compete in this domain Ericsson for his part devoted intensive and conscientious work to the improvement of his products, instruments, switchboards etc.

A clash with the Americans became unavoidable. It took place in the beginning of 1881 in conjunction with the question of the introduction of public telephones in Gefle. As the outcome of this competition was to be of decisive importance for the future expansion of the infant Swedish telephone industry and was even to open the door for its progress abroad, a brief account may here be given of the course of the struggle. It should be recalled that the widely extended American Bell Co. was at that time already strong and dominating with great technical resources according to conditions then existing, while their opponents constituted solely of the two mechanics L M Ericsson and C J Andersson.

At the beginning of 1881 the Bell Company in Stockholm offered to instal and operate a telephone network in Gefle for a price of 200 kronor per subscriber and year, on condition that at least 50 subscribers signed contracts for five years. But now competition appeared on the scene. Basing on prices and estimates from L M Ericsson, J W Sundberg of Gefle handed in a tender to execute the installation itself for 275 kronor per subscriber and thereafter to operate it for an annual subscription of 56 kronor, all on the condition of at least 50 subscribers. At the end of January there were set up for comparative tests a couple of instruments from the Bell Company and from »the Instrumentfirm Ericsson & Co.». Representatives of the press were first asked to test the installations. »Gefleposten» certified that both functioned very well, but considered Ericsson's instruments were »simpler, stronger and more attractive». Nevertheless, the Exchange Association of the city, which had charge of the question, decided to call in three advisers, two telegraph men and one technician, Lieutenant P G Lindahl. At a meeting on 15th February Lindahl presented a report in which it was stated: »The inspectors had found Ericsson's telephone to be better made, provided with a better ringing device and with a better designed and movable microphone than Bell's whose generator instrument for the ringing circuit has the fault that it deteriorates as years go by.»

There was then formed the Gefle Telephone Society with 57 members. On 25th February it decided to accept Mr. Sundbergs abovenamed tender — cut down to a certain extent — which means that Ericsson's instruments were to be employed.

The descision in Gefle was not only a fine local success for Ericsson and his make, gained by superiority of quality and lower price; it had a very much more extensive significance. As a matter of fact it was to act as an impulse to an unexampled rapid spread of the telephone in Sweden and neighbouring countries.

It is outside the scope of this article to seek to enquire into the details of the reasons for this phenomenon; one which chiefly contributed was without a doubt the possibility of obtaining at low prices first-class material of Swedish make, while the experience in the domain of telephony which Ericsson and his staff were gathering to an ever greater extent was constantly at the disposal of customers. At a number of places, both urban and rural, cooperative associations were formed which could offer their members exceptionally advantageous subscription terms and therefore found enthusiastic support. All were to have Ericsson's material and for this reason the workshop had time and again to increase its capacity.

It has been suggested above that the outcome of the Gefle battle also opened the door of foreign markets for Ericsson. Here it will suffice to give one of the first and most tangible evidences of this. It comes from the old Hanseatic town of Bergen in Norway. There, as in several other Norwegian cities — Christiania, Drammen and others — the international Bell Company had applied for concession to carry on telephone operation. In the capital and in Drammen the applications had been granted; in Bergen, however, things went differently. While in the beginning of 1881 the question was being eagerly discussed in the newspapers and otherwise whether the concession should be granted or whether the city should take the matter in its own hands through a society of interested citizens, there came the news of the Swedish telephones and gave a new turn to the discussion. In the Bergen newspapers of 2nd March 1881 the telegraph manager O Norshuus, who as an expert was interested in the telephone question, published his opinion of the different proposals. In this he stated: »From what has transpired up to now it seems to be a question of introducing here a Swedish instrument that has come out recently at a comparatively moderate price concerning which the 'Gefleposten' writes: 'Lieutenant Lindahl reports' etc.» (here is given a copy of the above-named report by the advisers in Gefle on the tests that had been made). Norshuus closes his statement with the words: »Ericsson's instruments have now been submitted to the test in Christianstad and according to reports they have been preferred to the American instruments. A couple of the former instruments will shortly be submitted to me and then opportunity will be given to the public to submit them to trial.»

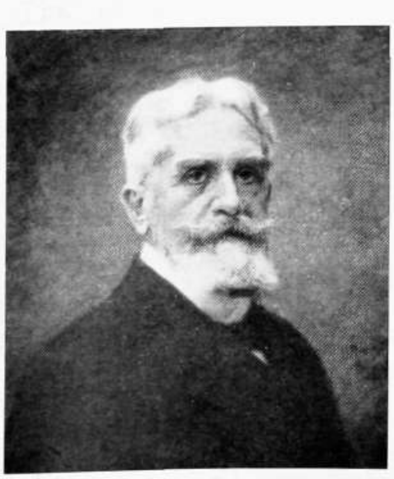
Soon afterwards the Bergen Telephone Company was formed and Ericsson had acquired a firm position in Norway.

These episodes from Gefle and Bergen may possibly appear to a present day observer as of little significance. Nevertheless they constituted the breaking of the ground for the Swedish telephone industry in Sweden and its nearest neighbour countries. Ericsson had demonstrated the ability of this industry, despite relatively small resources, to engage in victorious struggle with the strong Bell concern both inside and outside the country, a circumstance which formed the basis not only of the great progress of the Ericsson undertaking but also for the subsequent intensive expansion of telephone activity in the Northern countries.

The engineer H. T. Cedergren of Stockholm was probably the first to realise clearly the importance for the life of the community the telephone might assume if its exploitation was directed along proper lines, which in his opinion was not the case in Sweden where the rates applied by the Bell Companies were almost prohibitive. When, to carry out his plans — the spread of the telephone in the widest circles (»the telephone in each home in Stockholm» to begin with) — he founded in April 1883 Stockholms Allmänna Telefonaktiebolag (the Stockholm Public Telephone Company), Ericsson's workshop had been devoted to telephony for 5 years and had gained a reputation for first-class products. What then was more natural for Cedergren than to consult Ericsson in regard to his plans in general, in the first place concerning the prospects of obtaining inside the country the material for carrying them out?

To begin with Ericsson with his cautious nature seems to have adopted a rather hesitating attitude to the audacious proposal; he was of course well aware that neither Cedergren nor any associates he had in mind possessed any experience in the domain of telephone operation either technically or financially. Nevertheless Cedergren succeeded by his enthusiasm in interesting Ericsson; the new undertaking therefore enjoyed the advantage of Ericsson's support as designer and manufacturer, which undoubtedly was of inestimable value. Indeed collaboration with Ericsson would seem to have been an essential if not an absolutely necessary condition for the realization of Cedergren's plans. Where otherwise could Cedergren have turned to satisfy his requirements of material? The Americans, whose largest plant in Sweden, the Stockholm Bell Company he aimed to beat in competition, he neither could nor would rely on. That Ericsson's business was of the greatest importance for the start and development of Stockholms Allmänna Telefonaktiebolag as indeed for Swedish telephone activity on the whole, is beyond all doubt. The collaboration between Ericsson and Cedergren continued with only one serious interruption until Ericsson retired from business, *i. e.*, for 20 years, and contributed very greatly to the building up of an outstanding world-wide industry that brought honour to Sweden and an international business enterprise of great scope.

Ericsson also provided the initial impulse for the creation of another enterprise that was later to grow into a great industry. In 1888 the brothers Max and Ernst Sievert, of whom the former had for a number of years represented in Sweden a foreign manufacture of covered copper wire, opened a factory at Sundbyberg, for the production of such wire. This plant, which under the name of »Sieverts Kabelverk» has gained a market and recognition for its products far beyond the borders of Sweden came into existence on the initiative of Ericsson.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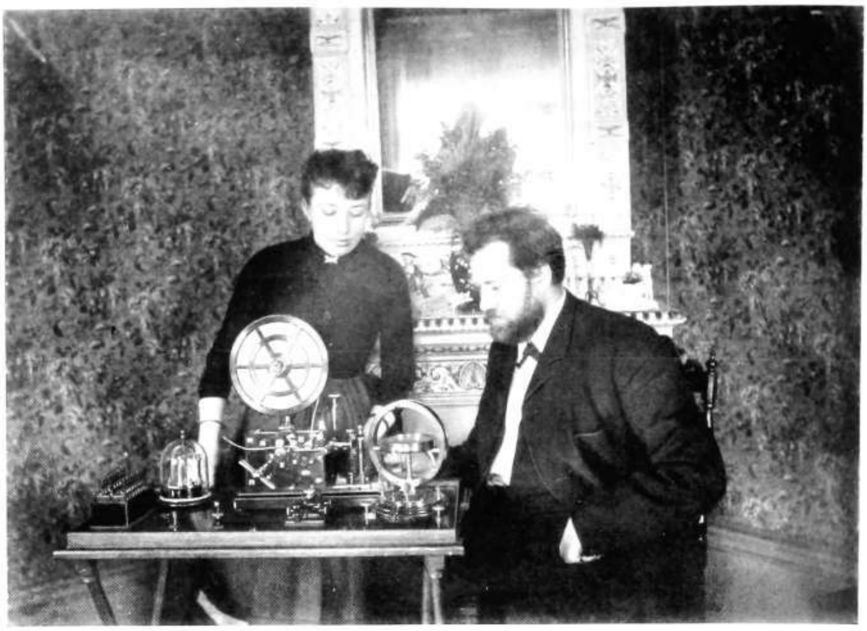
H T Cedergren

The cases of Cedergren and Sievert constitute good examples of how an able and energetic industrial leader during the early progress of Swedish industry



X 6158

Lars Magnus Ericsson and his wife
with some instruments designed by the husband

could have an initiating and supporting influence in the building up of other big undertakings.

It has just been stated that Ericsson had great need of wound copper wire of various kinds; a considerable proportion of this consisted of silk-insulated copper wire for winding electro-magnet reels, used to a great extent in the telephone and other weak current industries. In his wife, Hilda, née Simonsson, whom he married in 1878, Ericsson had a partner not only in household matters but also in the work of his business. The winding of electro-magnet reels — typical woman's work, if such differentiation can be made in these days when even work on the big machine tools is entrusted to representatives of the »weaker sex» — was in the early years done by Mrs. Ericsson, first alone and later as the quantities grew with the aid of one or more assistants. It is narrated that when she for some reasons or other had to keep to her bed this did not prevent her continuing her work with the winding machine on her knees. There is no doubt that Ericsson in other matters also benefited by his wife's practical mind and wise counsel. One of our illustrations shows the Ericsson couple in discussion on some instruments designed by the husband, including one for the demonstration of the effects of electric current (the photograph was probably taken by Max Sievert, who was not only one of Ericsson's suppliers but also his friend socially).

What Ericsson and his work meant for Swedish technical and Swedish industrial life can naturally clearly be illustrated by complete particulars and figures. Here, however, will only be presented sufficient to characterise developements up to the year 1903 when Ericsson definitely retired.

As stated the number of hands at the close of 1882 was about 50. A little more than a year afterwards, with the working force approaching 100, Ericsson found himself obliged to find more accommodation than the premises at Biblioteksgatan provided. He bought some property on Tulegatan and had erected there a building, which could be taken into use towards the close of 1884. Some years later an adjoining property on Rådmansgatan was purchased, a building necessary for business extensions being put up there. The last extension during Ericsson's time took place at the beginning of the new century when on three plots of land in Tulegatan there was erected a factory building regarded as most up-to-date according to standards of those days. The number of hands employed in the whole range of factories at the time Ericsson left in May 1903 was around 1 000. As regards manufacture it was customary as a rough approximation to take the number of complete telephone instruments delivered, but it should be noted that the value of other products of various kinds leaving the factory generally represented at least as large an amount. The following figures speak for themselves! In December 1883 instrument No. 5 000 was adjusted; in June 1896 No. 10 000; in January 1903 No. 400 000 (and in February 1912 No. 1 000 000). It is obvious that such quantities coul not find a market inside the country; an appreciable number was exported. Even in the early eighties, as we have seen, Ericsson's manufactures had found their way abroad, in the first place to neighbouring Northern countries, and in the nineties the foreign business became ever more extensive. In some years the value of exports amounted to 60, 70 even up to 85 % of the total sales. Buyers were to be found in practically every country of the world but the chief sales areas were the Northern countries, Russia and Britain with her colonies and Dominions.

In order to satisfy the increasing demands of the most outstanding foreign customers Ericsson found himself obliged to set up branch establishments in certain countries. Thus in 1897 a factory was opened in St. Petersburg which by extensions a couple of years later attained a very large production; the following year a branch office was established in London supplemented in 1903 by a factory, and a branch office was likewise opened in New York in 1902. Moreover Ericsson had at his disposal a widespread network of agents in all parts of the world.

In 1896, as stated, Ericsson transferred the business to a company with a share capital of one million kronor. At the beginning of 1901 the capital was increased by drawing on the company's own reserves to make a total of 3 400 000 kronor, of which 400 000 kronor was employed for the purchase of an undertaking with the name Aktiebolaget Telefonfabriken, established four years earlier by Stockholms Allmänna Telefonaktiebolag.

For something over four years, up to the autumn of 1900, Ericsson guided the fate of his undertaking as managing director. But right up to May 1903 he continued to display interest in its activities. He then considered that the time had come to retire and he passed over his shareholdings to other hands.

Ericsson had now given up his great life work, but by no means with the object of enjoying the life of leisure he had well earned. Barely over 57 years he was in the full prime of life and he was well able to utilise his energy in a domain to which he had been devoting an interest for some years, farming and all that goes with it. In the estate of Ahlby, near Fittja, which he purchased in 1896 he invested large sums and put in considerable work with the object of rationalising and that gave him also opportunity to continue to satisfy his love for the work of designing. In 1916 Ahlby was taken over by his youngest son and Ericsson himself went over to the neighbouring property of Hågelby. There too he could satisfy his unquenchable thirst for work; but gradually, however, this strong man had to yield to the demands of increasing age. His greatest affliction seems to have been the progressive failing of his sight, which first deprived him of the possibility of using his dearest tools, the drawing board and drawing instruments, and later forced him to give up the society of other silent friends, books. In his later years his continual great thirst for news and knowledge could only be satisfied by having someone to read to him.

On 17th December 1926 Lars Magnus Ericsson passed away, 80½ years old. In the centuries old sanctuary of Botkyrka his remains were laid to rest on 22nd December. No speeches of tribute were allowed at the burial, no reference was made to the noteworthy lifework of the deceased, no monument shows the place in the churchchyard where his remains rest. »Nameless I came into the world, nameless will I depart.»

So appeared the outer framework of Lars Magnus Ericsson's life. But what of the man, what qualities constituted the causes of his appreciable and

X 6161

Lars Magnus Ericsson's grave in Botkyrka churchyard

immediately after the interment on 22nd December 1926

successful contributions to the industry of his country? The present writer was in close contact with Ericsson during the last three decades of his life — an intimate collaboration during the five years 1898—1903 — and will attempt to give a reply, by no means exhaustive, to these questions.

Ericsson was, as will have been seen, in all respect a »selfmade» man. From his 14th year he had had to shift for himself. Thanks to inborn talent and an alert and keen vision and stubborn purposeful energy he acquired a considerable amount of knowledge, not only in the sphere most nearly connected with his activity but also in other domains.

A strong feeling of respect and maybe also of inferiority was the impression that Ericsson gave at the first encounter. His outer appearance was impressive, his attitude unassuming but marked by ingrained grandeur and dignity, his utterances were always well considered, wise and logical; acquaintance had not proceded far before one realised that the spiritual powers were no less impressive than the secular. At the beginning one's feeling of inferiority could be stifling, perhaps even hindering the development of one's own powers. But having found that beneath the apparently cold exterior there were concealed a warm heart and a sterling character, the feeling of inferiority gave place to an affection which grew in strength the more one learned to know the true personality.

Ericsson possessed great ability for directing his subordinates and gaining their respect, even though this to a certain extent might have been veiled by the moderation and consideration which constituted an outstanding feature of his character. His orders were often garbed in the soft folds of wishes, without thereby losing anything of their force. His temperament was even and the writer cannot recall a single example of Ericsson forgetting himself even under difficult and exacting situations. Wrathful words and reproaches were foreign to him. If he had reason for displeasure this found its expression in biting sarcasm and reflexions which though pointed were politely expressed, all of which possibly had a greater effect on the victim than if the correction had consisted of invective.

Among his workers Ericsson possessed an authority that recognised by all. His great knowledge of workshop practice, his generally known skill both in the design and execution of an object and his genial and unaffected manner of dealing with the staff had the result that all not only respected

L.M.ERICSSON.

X 6160

Lars Magnus Ericsson
portrait by Axel Jungstedt 1905

and looked up to him but also had a warm affection for him and tried to do their best to please him. It was a kind of patriarchal relation, a mutual trustful cooperation that prevailed, to the benefit both of the parties themselves and of the work they had to do.

One of Ericsson's outstanding qualities was caution, in business and in other matters. Many who had dealings with him considered him a pronunced pessimist. While he was at the zenith of his life work and success grew almost from day to day he might let drop an utterance something like: »Yes, it's all very well that we are full up with work. But the demand for telephones in the world would seem to be nearly filled and then where shall we get work? It might be better to start making consumption goods, matches or something like that.» Certainly such an utterance displays no prophetic vision into the development of telephony. But how many had such vision in those days? The view of things thus expressed constituted a faithfully followed guiding star in Ericsson's business; in this the term speculation was allowed no part. Which nevertheless did not prevent him when a desirable goal was to be gained from making a powerful contribution, such as when at a moment of importance for the development of the undertaking he quickly decided personally to make an appreciable capital investment in a new and promising telephone company abroad so that thereby that company's orders for material would come to his concern. For my part I cherish the opinion that Ericsson's nature was at the bottom optimistic. Extremely cautious he was, but between pessimism and caution there is a wide gulf. His energy and capacity for work, his intense love of work and his conduct in dailv life were not the characteristics of a pessimist.

Energy and capacity for work — these bring us to one of the most important chapters of the reasons for Ericsson's success. When the writer entered his service Ericsson was in his full prime, 52 years old. The amount of work he could perform was incredible. Often he brought with him in the morning at the opening of the office a sketch or a drawing of a design that he had worked out the previous evening or night or that he had put on paper during the boat trip into town from his beloved Ahlby. The whole day long he was occupied with organising and supervising the work out in the workshop, interested in the slightest details, with interruptions for discussions of business matters in the office and for participation in and supervision of the work of the drawing office. »Standard working day» was and had always been an unknown conception for Ericsson. The close of regular working hours signified most often for him merely that he returned to his beloved drawing board where undisturbed he could devote himself to his favourite occupation. Or maybe trials and experiments with new instruments and apparatus took up a great part of the hours which by others were reserved for entertainment and rest. That a 57 year old man after a long life of work, full of labour and care, might feel weary and want to retire seems hardly unnatural. Yet it seems that in the main at least it was not such reasons that led to his retirement as early as it occurred. His decision would seem to have been greatly influenced by the thought, disquieting for him with his strong feeling of responsibility, that the extent of the business made it no longer possible to follow and master every detail of the work as he had been accustomed to do, which for a man of his nature was a »sine qua non».

The quality in Ericsson which by his work became most generally known and which is usually given the greatest credit for his success and renown was his skill as designer and inventor. Unlike his famous namesake John Ericsson — likewise a son of Värmland — Lars Magnus Ericsson was not to be counted among the great inventors. Certainly there were born in his brain many ideas of value technically; but it cannot be said that any of really epoch-making importance emanated from him. In his eyes an invention was not an end in itself but only a means. His inventions may be said to represent stages in a constantly proceeding energetic work to develope and improve the branch of electrotechnics to which he had devoted himself.

An account of everything of value in the field of telephony that was created by Ericsson's genious and knowledge would take up far too much space; only a few random examples from the abundant store will be given. Ericsson was the first to give the telephone instrument and its more important components a light and attractive form without in the slightest degree neglecting efficiency. In this respect Ericsson's products were far in front of the heavy ugly types put on the market by American and other foreign factories and they were therefore the object of inumerable imitations, none of which, however, attained the quality of the original.

Ericsson's first transmitter, »the spiral microphone» of 1880, was an original and ingenious design which certainly had great importance for the development of telephone service in Sweden and neighbouring countries. Before the introduction of the carbon transmitter — in which domain Ericsson also did some fine work — now universally employed in hundreds of variations, the spiral microphone seems to have been one of the leading designs.

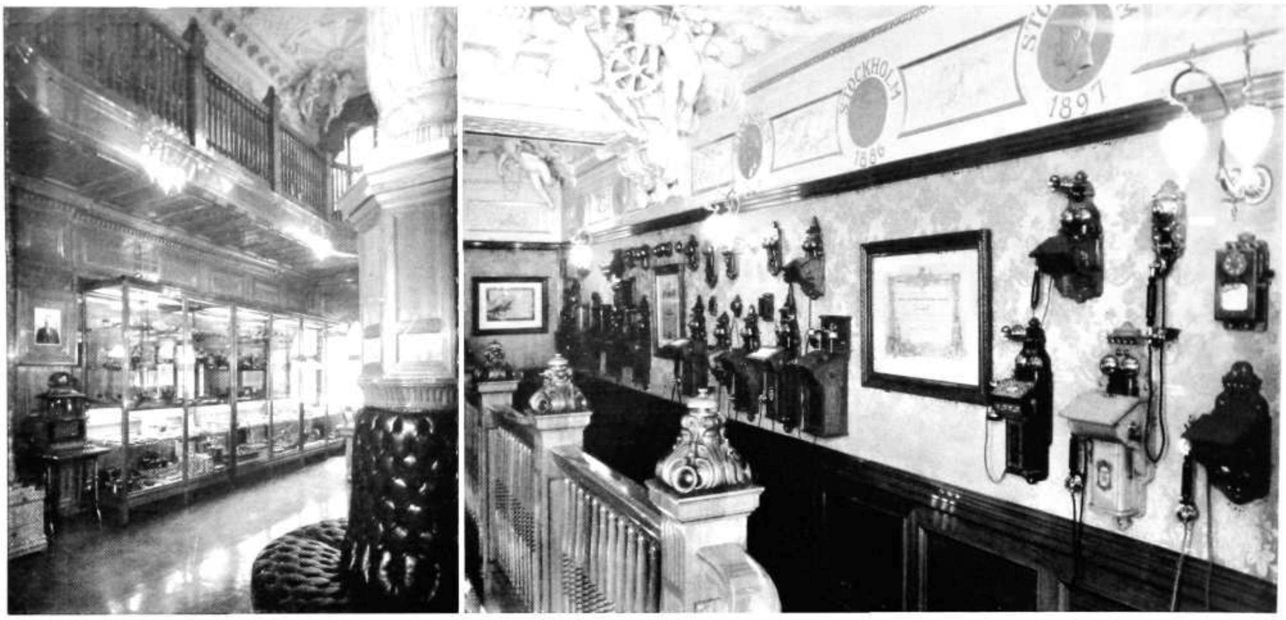
The first idea of combination of receiver and transmitter — the handset — did not perhaps spring from Ericsson's brain; still it was he who gave this important component its practical shaping and put it on the markets of the world, where it may now be said to have entirely established itself, since foreign manufacturers after many years of stubborn opposition have been obliged to accept the idea owing to pressure from their customers. In the domain of telephone exchanges Ericsson likewise made appreciable contributions. In 1884 he designed and made for account of Stockholms Allmänna Telefonaktiebolag the first multiple desk in Europe. In the concluding years of his business activity he participated with great interest in the design and shaping of the details in the central battery system, then quite new. It might also be recalled that Ericsson in conjunction with Cedergren as early as 1883 had a couple of automatic connecting instruments so perfectly developed that by employing them Cedergren could offer particularly cheap subscription in his undertaking, Stockholms Allmänna Telefonaktiebolag. How the credit for the introduction of these switchboards is to be distributed between Ericsson and Cedergren it is now impossible to decide. Probably the suggestion came from Cedergren, who of course was extremely interested in getting the undertaking he had planned in operation. The development of the design, however, would have been entrusted to Ericsson. It may be mentioned that a large number of these switchboards are still employed both in Sweden and abroad, chiefly in Stockholm.

As designer, as in other respects, Ericsson was a »selfmade» man. Perhaps the expression may not be considered wholly adequate; he was a genius in that sphere, and a genius is not created by study. Persons observing Ericssons's way of working gained the impression that the design was definite and complete for his inner mind before he gave it form on the paper. So rapid and sure was the procedure. His work at the drawing board was lightened in high degree by Ericsson's thorough knowledge of his trade and all its points. He could see to the last detail how the instrument engaging his thoughts for the moment should be built up so that it could be produced in the most simple and efficient manner. He could also clearly see what demands should be made on a design intended for a certain purpose and the best manner of meeting those demands. A strong feeling of the significance of externals led him always to try to give his work an attractive appearance. And, last but not least, he put the demand for quality of execution exceedingly high, applying it to all details from the first operations in press and lathe to the giving of the final finish. In this respect he was a pioneer of great weight in telephony. His principles concerning the execution of the work raised manufacture to a higher plane than the foreign telephone factories had considered necessary to maintain; these latter were gradually compelled to try to apply the same principles, a circumstance which was to be of great benefit for this ever more universal and indispensable means of communication. The solid quality of Ericsson's work in conjunction with the elegance of design is what ensured for the »L M Ericsson» mark a general recognition as a symbol of high quality. In one of the British Dominions where the Ericsson make had acquired a large market, the Telephone Administration declared »The Ericsson instrument is the Rolls-Royce of telephones».

A characteristic example of how an accurate and elegant piece of work could act on Ericsson's feelings may be cited. During a visit to the U. S. A. in 1901, in company with H. T. Cedergren and others, he bought an automatic pistol of the famous »Colt» make. The sturdy and elegant work pleased Ericsson's trained eye and it is declared by his fellow-passengers that on the return voyage, whenever he felt at all depressed, he would take out his newly acquired treasure and gaze on it. Immediately his spirits improved and life seemed brighter.

Ericsson had little time to spare for amusement and other recreation. He was a hermit to the extent that he wasted no time on festivities, be they private or public. Lack of pretension, not to say shyness, made him avoid such occasions; there he ran the risk of attracting attention, a thing that he detested.

Many external marks of distinction came to him; probably he valued them but little, but at the same time he may have feared that refusal to accept them might attract just that attention which he found displeasing. In any case he evaded — as far as the writer knows — every occasion when he might be required to wear them. Nevertheless on one occasion he felt himself compelled to decline an outstanding honour. It was when the Stockholm University in 1909 wanted to create him Honorary Doctor of Philosophy. His response was in the following characteristic terms: »As I have been confined to bed for



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Inside views of the L M Ericsson memorial hall

located at Thulegatan 17. The hall was presented on 12th May 1943 to the City of Stockholm, which undertook to preserve and look after the room and its exhibits for posterity.

some days by illness it is only now that I am in a position to acknowledge your communication of the 30th ult. It constituted for me a surprise which carried with it deeply felt gratitude for the kind thought of the faculty for my person. Still, as my consciousness cannot overshadow my lack of qualification for the honourable distinction in question, I am compelled for my own peace of mind respectfully to decline it. Nevertheless I shall always cherish a grateful remembrance of the faculty's kind intention.»

To be in a position to present a correct and complete picture of Lars Magnus Ericsson's personality one must have been associated with him also away from work, in his home. In his Ahlby, where he and his wife had made for themselves a substantial home with the simplicity of a Tusculum, he was by no means a hermit. There as host he displayed the greatest hospitality and amiability and his pleasure in welcoming friends of various classes was great and unfeigned. On such occasions he could give free rein to gay spirits and let his sense of humour have play without the restraint which he might have thought should be maintained during working hours.

Lars Magnus Ericsson was a great man of labour. The whole of his life was a hymn of devotion to work. By his capacity of work, his genius and his energy, combined with solid aspects of character, he built up in the course of only 27 years, in harmonious collaboration unmarked by differences with his employees, an undertaking the products of which stretched out to the farthest corners of the world, bearing the name of their originator to circles wider perhaps than any other Swede's name has reached.

Developments in Teletechnics

1846—1946

Telegraphy and Telephony
Tele-signalling
Radio-Technics

Telegraphy and Telephony

N HEDEN, LATE DEPARTMENTAL HEAD IN SWEDISH TELEGRAPH ADMINISTRATION, STOCKHOLM

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Telegraphy

After *Volta* in 1799 had constructed his electric pile, thus demonstrating galvanic electricity, proposals were immediately put forward for remote signalling by employment of *Galvani's* frog preparation, and 10 years later *Sömmering* performed a kind of telegraphy based on the property of the electric current to split up water. None of these methods, however, was given any practical application. Other discoveries were to open the way to serviceable telegraph systems. These discoveries were made in 1820 when *Oersted* demonstrated the action of the electric current on a *magnet needle* and when *Arago* found that iron could be made magnetic by a current path wound round the iron. *Sturgeon* some years later indicated, by application of Arago's discovery, how a powerful *electro-magnet* could be constructed. Thus electric telegraphy developed along two lines both in the form of needle telegraphs and of electro-magnetic telegraphs.

The First Telegraph Systems

The first *needle telegraph* was designed by the Russian scientist *Schilling von Cannstadt* and was exhibited at the Natural Science Meeting at Bonn in 1835. The idea then became generally known, but even a couple of years before *Gauss* and *Weber* at Göttingen had a local needle telegraph installation, which was destroyed by lightning, however, in 1837. It was the English and Americans who, after numerous trials, were able to make a start with the operation of needle telegraphs. On the railways of the United States and Great Britain this very desirable accessory for traffic safety came into use around 1845. France followed shortly after and there too the needle telegraph became widespread.

The fundamental design for the *electro-magnetic telegraphs* was worked out by *Samuel F. B. Morse*. He was an American and painter of historic pictures by profession and had not previously been either physicist or engineer. Nevertheless in 1832, during a visit to Europe, he hit on the idea of employing the electro-magnet as receiver and quite unaided he worked out his first design, which he demonstrated publicly in 1837. He then entered into relations with Professor *Gale* and two engineers, the brothers *Vail*, and the design was improved by them jointly until it was in working condition. About the same time Morse published the first dot-dash alphabet which in its modified state still bears his name. The first Morse line of communication of any length was put into service in 1844 on a 64 km long circuit between Washington and Baltimore. Starting with 1845 the Morse system was introduced generally into the United States; two years later there were about 1 600 km of lines and by 1852 the length of lines had increased to nearly 40 000 km.

Morse telegraphy had thus conquered America, but as the needle telegraphy had already got a hold in the west of Europe the opposition there to the new system was extensive. Germany and Austria were therefore the first European countries to employ the American system. The first Morse circuit in Europe was constructed in 1850, between Hamburg and Cuxhaven. After Siemens & Halske took up the manufacture of Morse equipments the system became more and more general in the 1850s.

Two other telegraph systems, both based on the electro-magnet, had come out before 1846, however. *Wheatstone* in collaboration with *Cooke* used alternating current for transmission and a polarised magnet for receiving, the latter driving a pointer step-by-step. Under the name of Wheatstone's A-B-C system, the dial telegraph was adopted in England and, after Siemens & Halske in 1857 had improved the instrument, dial telegraphs were introduced also on the railways of the Continent and in Sweden. The other system, the letter-printing system, also employs the step-by-step principle, but in combination with a type-wheel.

We have now arrived at the year of L M Ericsson's birth, 1846.

The First Spreading of Telegraph Networks

There is no epoch-making discovery made just that year to report, but at that date there existed many possibilities for achieving rapid and reliable telegraphic communications, so that the latter half of the 1840s and the following decade became the time when telegraphy asserted itself. The United States of America continued to hold the lead. In Europe it was the railways at the beginning which were in the fore but in a short time private and state undertakings began to construct telegraph plants for public communications. England, France, Germany and Austria were among the first of the countries of Europe. The other countries were not long behind and when Greece put in its first plant there were telegraph communications in all European States. The first international communication was opened in 1849, between Prussia and Austria. The German States formed with the latter country a telegraphic union, after which joint traffic spread out over the whole Continent. As it was feared at the beginning that aerial lines would be far too much exposed to disturbance, underground cables were employed in many places but the trials did not prove satisfactory and aerial land lines were therefore generally preferred.

Submarine cables could of course not be avoided when it was desired to obtain communication with insular countries. The trials made with un-armoured cable failed but after going over to strong iron-wire armouring good results were achieved with a cable between Dover and Calais in 1851. In the following years a number of submarine cables were laid down in European waters, including one across the Sound between Sweden and Denmark, and now the demand for connection with North America grew increasingly insistent. Cable for the purpose was procured, but during the laying in 1857 this broke over an ocean depth of about 4 000 metres. The following year, however, a cable was successfully laid across the Atlantic, but after a few weeks working this ceased to operate in September 1858, probably owing to poor insulation. It was not until 1865 that the great ship »Great Eastern» was able to lay a third and better constructed cable, while at the same time the lost end of the 1857 cable was found and the laying of that one too could be completed. Thus at the close of 1865 there were two good quality Atlantic cables. Many more were added in the course of years and by 1874 practically all countries were linked up in the world telegraph network.

The importance of telegraphy for business communications of the day can hardly be over-estimated.

Governments soon had their interest awakened in the possibility of attaining rapid communication with their subordinate bodies, but were as a rule little disposed to give the public the same benefits. Where private undertakings put up telegraph plants, however, these were immediately thrown open for commercial traffic and the governments too — not to miss the profit obtainable — soon had to follow suit. The large business houses, thanks to their expensive but rapid courier systems had previously had an advantage over the smaller and financially weaker undertakings and could therefore better profit by rapidly changing prices. The opening of telegraphic facilities for all contributed to breaking the dominating influence of the big firms and provided possibilities of competition which in turn helped in the financial and technical advances evident in succeeding years, despite occasional setbacks.

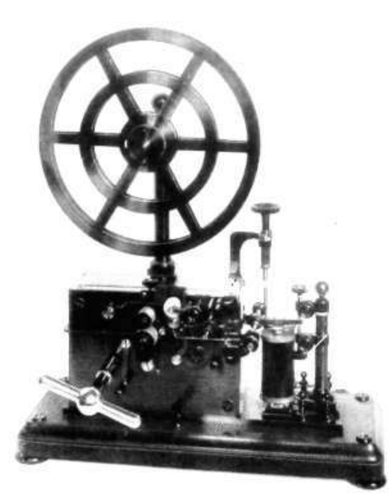


Fig. 1
Morse instrument

X 4435

The Introduction of Telegraphy into Sweden

Lack of interest and conflicting interests have often hampered early progress. This was the case when the telegraph was introduced into Sweden. In a written communication to King Oscar I in 1849 the American *Robinson* had offered to construct telegraphic connection between Stockholm and Gothenburg. The Chambers of Commerce in those cities did not anticipate any great utility from such a plant and would not contribute to the cost, so the Government let the matter drop. Though the public had begun to display interest in the matter, a fresh offer from Robinson the following year still failed to obtain Government support.

It was three Swedish military men that later took up the question afresh, General *Carl Akrell*, chief of the semaphore telegraphy, and Lieut-Colonel *J. F. von Heland* and Major *A. L. Fahnehjelm*. The last-named in the course of his work with the naval engineering corps had interested himself in the practical employment of galvanic electricity. In the years 1843—46 he designed in conjunction with v. Heland a telegraph instrument. During a journey abroad in 1850 Fahnehjelm made himself acquainted with the Hamburg-Cuxhaven plant and he bought a Morse instrument in Hamburg. With this as pattern two instruments were made in Sweden. Fahnehjelm and v. Heland carried out a number of experiments with these, and in the spring of 1852 they were in a position to exhibit a trial plant at the de la Croix gallery in Stockholm. Akrell by now had been entirely won over in the matter and he submitted to the King a proposal for a Swedish telegraph network to comprise Svealand and Götaland and which also envisaged communications with Denmark and Norway.

In the beginning of 1853 the Government gave its approval in principle to the plan. It was, however, restricted to the section Stockholm—Upsala—Örebro—Gothenburg, of which only the Stockholm—Upsala section was to be constructed immediately. On 16th June 1853 Sweden's first telegraph plant, Stockholm—Upsala, was ready for trials and in the autumn of the same year it was opened for public traffic. Von Heland became the head of the plant, Fahnehjelm chief of the Stockholm station and to the same position in Upsala was appointed A. H. Öller.

Akrell now submitted detailed proposals for the continuation of the line Upsala—Gothenburg and on via Helsingborg to Malmö, with branch line from Vänersborg to Norway and cable connection over the Sound to Denmark. In 1854, after funds had been voted, the work could be continued. It proceeded at such a rapid rate that Gothenburg could correspond with Stockholm by 4th July and the whole connection up to Malmö was completed by 28th August the same year.

The coming of the telegraph was celebrated in the different cities by great festivals, the newspapers were loud in praise and the ice was now broken. The Riksdag granted funds for fresh lines and construction was pressed forward to such an extent that in the next five years there were laid a main line via Norrköping and beyond along the whole of the east coast to Malmö and another via Gefle along the whole Norrland coast to Haparanda. In addition Norway was connected to Vänersborg via Uddevalla. Submarine cables had been laid across the Sound and between Västervik on the mainland and Visby on Gotland. By 1859 all county towns had received telegraph communications with the exception of Öresund, whose telegraph station was not installed until 1863.

The stations were equipped with Morse instruments. These had been made by different Swedish instrument-makers, among whom was F. J. Berg. After the above-mentioned A. H. Öller had become Director of the Stockholm telegraph station he opened in 1857 under the name of Öller & Co. an instrument-making shop. There both Morse instruments and other requisite station equipment were manufactured. The workshop was for long the main contractor for the telegraph administration and its new improved instruments also aroused attention abroad. It was also at Öller's workshop that L M Ericsson was to start his lifework in the domain of teletechnics.

The expansion of Sweden's telegraph network continued at a rapid pace if on a somewhat smaller scale during the 1860s. In the following decades the traffic in some years displayed stagnation or falling off, which was reflected in difficulty in getting the finances to balance and in the slowing down of the lay-out of new lines and stations or in total suspension some years. There was a disposition at the time to consider this due, in addition to the prevailing depression, to competition from the railway telegraphs and from the telephone introduced in the 1880s.

As regards railway telegraphs, it was found that the smaller places could manage with its facilities, though on the railways private correspondence could only be handled as a secondary matter. For a long time Siemen's and later L M Ericsson's dial instruments were those generally in use on the railways. Despite the fact that telegram traffic with these instruments was less sure than with the Morse instrument, the telegraphic facilities were of great benefit to the public and brought also to the State telegraph network a considerable amount of traffic.

Even the competition which the telephone exercised, especially over short distances, turned to the advantage of the telegraph after the Board of Telegraphs introduced the facility for private branch exchanges and subscribers to despatch and receive telegrams by telephone. There was also another way in which the telephone circuits were to furnish advantages to the telegraph. By providing a telephone circuit with transformers at both terminal points and, from the middle of transformer windings turned towards the line, tapping a line it was possible without disturbing the telephoning to obtain a single-wire telegraph circuit. The first such telegraph transforming was taken into service in 1896. Even twenty years earlier efforts had been made in two other ways to avoid expensive line construction and therefore augment the traffic capacity of the existing telegraph network, *viz:* by the introduction of the rapid-writer system and by duplex telegraphing.

Later Telegraph Systems

A change-over to rapid-writing was made in 1874 on the most heavily burdened lines, where the Wheatstone system had begun to be employed. The telegraph

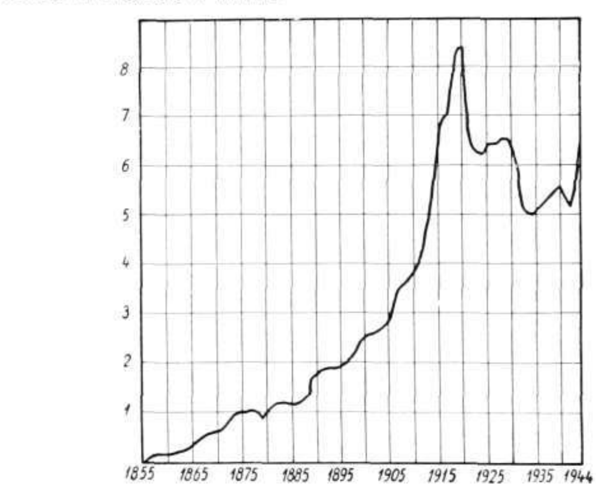


Fig. 2 X 6188
Graph showing the number of paying telegrams in Sweden for the years 1855—1944

signs are stamped out in paper strips by perforators. The perforated strips are fed into the transmitter which works at great speed. In the receiver, a modified Morse instrument with polarised magnet system, the signs are reproduced on telegraph strips. The system, owing to its reliability and its ability to deal with traffic blocks, has long been of great value.

The duplex-telegraphy, by means of which it is possible on a single wire to transmit in both directions, is based on a method worked out by the American *Stearn*. Duplex can be employed both with the Wheatstone system and in ordinary Morse telegraphy. The first employment of it in Sweden dates from the year 1878.

The graph of Fig. 2 shows development of telegram traffic in Sweden. A steady regular increase took place from 1889 up to the 1914—1918 world war.

Despite the fact that the above accessories enabled a great part of this increase to be coped with, it was still necessary to construct new telegraph circuits to a certain extent. The greatly increased requirements of circuits during and immediately after the 1914—1918 war necessitated during this period considerable construction. By 1924, however, the length of telegraph lines had reached its maximum. The laying of trunk cables had then begun and the telephone lines in these provided facilities for new telegraph circuits. When the aerial wires along the railway lines had to be taken down owing to electrification these were replaced by cable circuits.

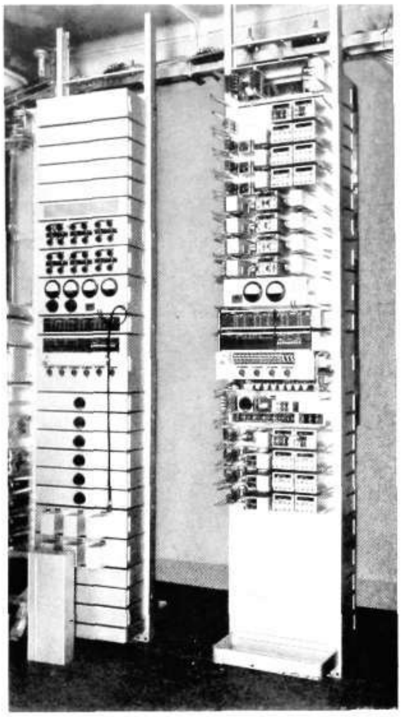


Fig. 3 X 4429
Rack for voice frequency telegraphs

For this purpose in Sweden three distinct systems were employed, *viz.*, cable telegraph, voice frequency telegraph and super-audio telegraphy.

The cable telegraph circuits are two-wire and without connection to earth. For telephone purposes all quads in the trunk cables are phantomised. If the middle of the phantom transformer winding towards the cable is taken out, there is obtained from each quad, in addition to three speech circuits, a single-wire line, and two of these form a super-phantoms circuit that can be utilised for telegraphing but not for telephony. Cable telegraphy is used on those sections where the demand for circuits is comparatively small.

Telephone lines are employed for *voice frequency circuits*. The frequency band that can be transmitted through the loaded cable line without too much distortion is divided up into a number of narrower bands, known as channels, each having its own carrier frequency. For this purpose one of the four-wire circuits of the cable is made available. It is possible to apply on each such circuit 24 channels in either direction and thus obtain 24 telegraphing facilities on each telephone circuit utilized. Equipment for these plants is supplied by LM Ericsson who are now also working on new and more up-to-date types of voice frequency telegraphy.

In *the super-audio telegraph system* there is employed only one carrier frequency, which lies higher than the frequencies required for good speech connection and is separated from these by filters. As with the cable telegraphy, the super-audio channel is obtained without decrease in telephone facilities. All super-audio equipments are supplied by LM Ericsson.

By the employment of telephone circuits for telegraph purposes the demand for aerial telegraph lines has fallen, so that the length of almost 44 000 km attained in 1924 has now been reduced to less than 4 000 km, while the telegraph channels in the telephone network have a total length of app. 103 000 km. The instruments and equipment for these channels are for the most part located at the cable repeater stations.

New instruments also have been introduced in the telegraph offices and now telewriters are almost exclusively used for the wired circuit telegraph traffic. Morse equipment is to be found now only at a few telegraph offices. Wheatstone instruments are still used for transit circuits of the Great Northern Telegraph Company but otherwise are now only kept as reserve.

Three machines of different makes are used for telewriting, *viz.*, Morkrum's teletype, Creed's teleprinter and Siemens' telewriter.

In recent years, with telewriter circuits rented out to a large extent to government administrations and private undertakings, the number of telewriters in service in the country now amounts to over 1 000. Plans and estimates for the introduction of subscriber telegraphy with automatic connection are being worked out.

Sweden's Telegraph Communications with other Countries

Mention has been made of the laying during the 1850s of submarine cable across the Sound. This cable was part of the Copenhagen—Helsingborg circuit, completed in the first days of 1855. The Danes had then their own telegraph office at Helsingborg, between which and the Swedish office the telegrams were carried by messengers. Direct communication was not arranged until five years later. By this time the need for more numerous and more sure communications with the Continent had arisen and a new cable to Denmark was laid in the autumn of 1863. During the Danish-German war in 1864 the telegraph lines were cut which hastened the laying in 1865 of a direct cable between Skåne in Sweden and Rügen in Germany. Keen interest at that time existed in Britain and America in a west-east transit connection through Sweden to Russia and applications for monopoly were made by several cable companies to the Swedish government, which, however, was not willing to grant any sole right. Moreover, Sweden for her own traffic with Europe had had to submit to high transit charges and it was realised that transiting through the country might provide a considerable income. Therefore when the Danish financier *C. F. Tietgen* in collaboration with foreign cable companies had begun to acquire concessions in other countries and then addressed himself to the Swedish government his proposal was favourably received though with certain reservations, and in June 1869 Sweden granted the first concession to Tietgen which he subsequently passed over to the company he established at the same time, the Great Northern Telegraph Company. By the concession Tietgen was under obligation to lay immediately a cable across the Åland Sea and later, as and when the Swedish and Russian governments required, to increase the number of circuits by this route. The Grisslehamn—Nystad cable was put into operation on 1st November 1869. After the Great Northern Company's concession had been extended to comprise communications from Sweden westwards the company laid in 1873 a cable with two wires between Marstrand and Skagen, from which junction was obtained with the Fanö—Calais and Hirtshals—Newbiggin cables. The transit lines through Sweden were laid and owned by the Swedish telegraph administration. Traffic on this route rose steadily and during the years 1877—90 two further cables were laid by the company across the Åland Sea and two cables between Gothenburg—Newcastle. The Great Northern Company's concession is still in force, though appreciably modified.

In 1898 a new telegraph cable to Germany was laid and the greatly increased continental traffic has since been provided for by submarine cables common to the telephone and telegraph.

The first telegraph circuit with Norway via Vänersborg was opened as early as 1855. New land circuits with Norway have since been arranged by lines from Gothenburg and Karlstad to Oslo, from Östersund to Trondheim and via Kiruna to Narvik. Transiting of Norwegian traffic over Swedish lines has also taken place. In 1856 Russia was connected via Torneå—Haparanda to the Swedish network. At the outbreak of war in 1939 Sweden had some 30 telegraph circuits with foreign countries. Most of these were cut by the belligerents and they have not all been restored yet. In place of them wireless telegraphy was arranged between Sweden and several countries, by which the greater part of traffic requirements could be satisfied.

Telephony

In the preceding section — on telegraphy — mention was made of Oersted's and Arago's discoveries. In 1831 *Faraday* demonstrated that, if a line circuit encloses a magnetic field and the field intensity is altered, current is produced in the line circuit. This research discovery constituted the necessary foundation for the transmission of speech with the assistance of electricity. Below will be dealt with first the basic components which together form a telephone instrument.

The Receiver

In 1837 the American *Page* performed an experiment by which he fitted a wire spiral between the poles of a horseshoe magnet. When circuit was made or broken in the wire spiral a sound was produced by the magnet. This, known as Page effect, was due to small alterations in shape of the magnet and was used by the German *Reis* in the receiver made by him, which consisted of an iron wire wound with copper wire. The device was fixed on a sounding box so that the sound might be better heard.

Reis, who gave his design the name of telephone, carried out his work during the years 1860—63. A couple of years later the American *Yeates* took up similar experiments and further attempts in the same style were made in 1874 by *Elisha Gray*. But some years earlier, 1868, the American *House*, who was working in the domain of telegraphy, produced a sound receiver for telegraphy, which might with advantage have been used for the reception of speech if only the inventor had realized this possibility.

The man who was to come out with the final solution of the telephone problem was the American *Alexander Graham Bell*. It is true that he had many experiments by other research scholars to rely upon but, unlike his predecessors, he had by study of *Helmholz'* experiments realised that articulated speech contained a multitude of tones combined together. He gives expression to this experience in one of the instruments first produced. This consisted of a strong electro-magnet in the form of a horseshoe the arms of which were provided with a number of steel laminations, as in a musical box. These laminations were tuned to a scale of tones. Technically the instrument should have been capable of reproducing speech with correct timbre, but Bell soon found that the requisite number of laminations would have to be unreasonably large. However, he arrived at another and simpler solution by fixing the iron armature of the electro-magnet on a diaphragm, in the first design a thin gold leaf. This device proved capable of replacing all the laminations.

Now Bell had his receiver clear in principle and he announced it in 1876 in his first application for patent. Soon afterwards he replaced the gold leaf and the special armature by an iron or steel diaphragm and the electro-magnet was made with a permanent rod magnet on one pole, on which there was fitted a wire coil with soft iron core. In this way, at the beginning of 1877, the receiver had obtained the external shape which it was to retain for many years.

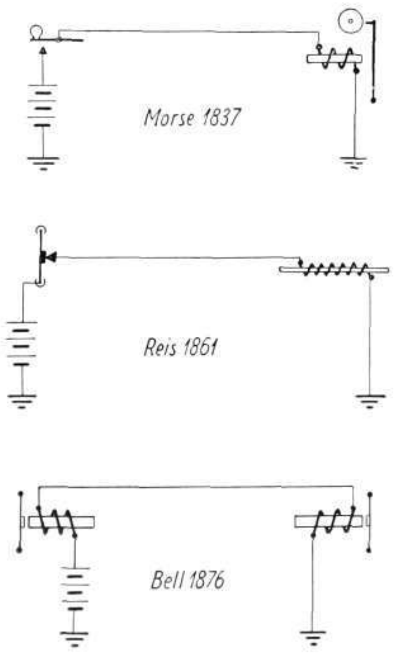


Fig. 4 X 4417
Comparison of the principles for Morse's, Reis' and Bell's designs

The Transmitter or Microphone

The distinction noticed by Bell between the pure musical tones and articulated speech with its consonant sounds and its varying timbre was of decisive significance for the design of a transmitter.

When single tones were to be transmitted this was possible to arrange, if only the intermittent circuit break or make were in time to the cycles of the tone, but in transmission of speech all the frequencies comprised in it with their mutually varying amplitudes had to be transmitted simultaneously. The valve regulating this undulating current should not in any case entirely break the line circuit.

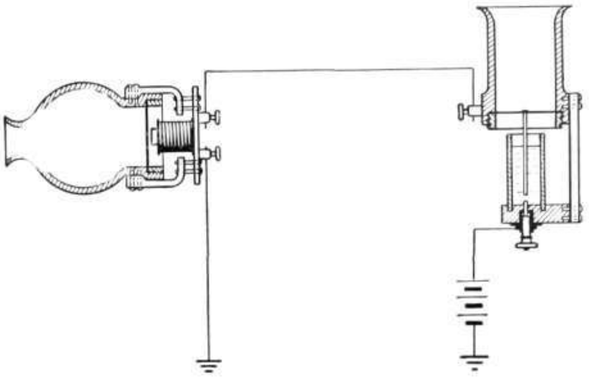


Fig. 5 X 6187
Grey's drawing for patent, 1876

Reis in his instrument employed as transmitter a spring with platinum point which made contact with a platinum plate fixed on a diaphragm. When the current conveyed through the contact was broken and made alternatively by the oscillations of the diaphragm the instrument could certainly reproduce the tones clearly if not perfectly, but of the speech there came out only a word here and there. Results were somewhat better with the Yeates' instrument but only when the contact had accidently become damp. Neither Reis' or Yeates' instruments were ever used in practice and they were forgotten for a long time.

When Gray in 1874 designed his electro-harmonic telegraph employing automatic interrupters tuned for different tones he was approaching the idea Bell applied in his laminated instrument. It was only later that Gray arrived at a transmitter that worked with resistance variations. Gray then used a vessel containing a fluid with low conductor property. From the bottom of the vessel there stood up a wire with platinum point. In a steel diaphragm above the vessel there was fixed another wire with similar point, this being submerged in the fluid to an appropriate distance from the fixed platinum paint. When the diaphragm was caused to oscillate, variations were produced in the circuit made through the layer of fluid between the wire points, owing to the changes in resistance.

Bell solved the question of transmission by simply employing the same kind of instrument both for receiving and transmitting. This is indicated also in the drawing for patent which he submitted on 14th February 1876. On the same day, but some hours later, Gray handed in an interim patent application (caveat) for his design already completed, to prevent Bell's patent, but this did not succeed. Gray's transmitter was that described above and his receiver differed little from Bell's.

The employment of receiver as transmitter was soon found lacking in efficiency and Bell went over to the use of different instruments for receiving and transmitting, as Gray had done earlier. Approach was again being made to Reis' design but the aim was to arrive at a contact which did not cause break but produced a resistance changeable according to the variations of sound pressure.

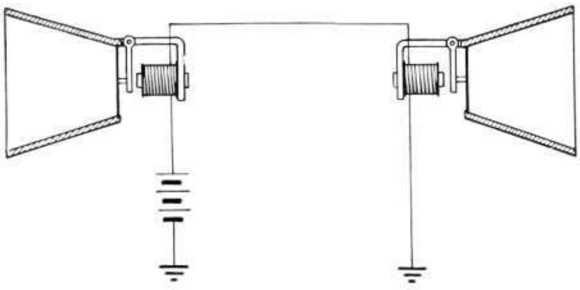


Fig. 6 X 6186
Bell's drawing for patent, 1876

It was *Edison* who first of all used carbon electrodes. In collaboration with *Phelps* he made a transmitter with contact between a carbon plate and a disc of platinum. Some months earlier, however, Edison's countryman *Blake* had obtained a patent for a transmitter that also had carbon-platinum contact. Compared with that of Edison-Phelps the design of Blake gave better facilities for accurate adjustment, a property on which the utility of these contacts was highly dependent.

Up to now in describing the different transmitters the word microphone has been avoided because it was Professor Hughes, mentioned in connection with telegraphy, who first made use of this name. Hughes demonstrated that a loose contact between two electrodes had much stronger valve effect than the fixed one used by Edison and Blake. The loose contact was formed of one or more carbon rods the ends of which were pivoted in hollowed pieces of carbon. It was, however, difficult to avoid intermittent interruptions in the line circuit, which spoilt the speech. A satisfactory solution of the microphone problem was brought out in 1881 when *Henry Hunnings* made public the principle of the carbon granule microphone, in which the space between the electrodes had been filled up with carbon granules of suitable kind and size.

Other Components of the Telephone Instrument

In the first telephone instruments the battery was connected in series through the magnetic coil to the line. With increase in the line resistance the current variations became weaker and Edison introduced as early as 1877 a transformer, known as the induction coil, and two current circuits in the apparatus. In the microphone circuit are comprised then the battery, the microphone and one low ohm transformer winding. In the receiver circuit are connected the receiver and the other transformer windings in series with the line.

A complete telephone instrument also requires devices for giving and receiving signals. In the first stage signalling was done by battery and ordinary electric bell but after a couple of years A.C. signalling was introduced with magneto inductor as generator and polarised bell as receiver. The requisite switching over between speech and signal was first done by hand but later by means of the hook in which the receiver is hung. The telephone thus arrived at was in its practical form an American product and its introduction as means of communication also started in the U. S. A.

The Development of Telephone Networks in Different Countries

U. S. A.

As stated Bell and Gray put in their patent applications on the same day and the exploitation of the inventions was taken over, Bell's by a consortium formed by him, later the American Bell Telephone Company, and Gray's by the Western United Telegraph Company. Even in the 1870s the expansion of the telephone network was rapid. At the beginning of 1880 the number of instruments throughout the country was over 30 000 and only a year later it had more than doubled. The Bell Company established a countrywide organization and founded a number of subsidiary companies. One of these subsidiaries, the American Telephone & Telegraph Company (A. T. & T.) made greater progress than the parent company and the Bell Company was taken over by A. T. & T. in 1899. Ten years later the Western Union was also bought after which A. T. & T. had for a time almost a monopoly of telephone business in the States. In opposition to this with a certain support from the authorities there were formed around the beginning of the century more than a hundred so-called independent companies, which in 1907 had together a little more than 2 million subscribers against the four millions of the Bell Company. Later, however, some of the independent companies made agreements with A. T. & T. and formed what were called Associated Bell Companies. This was furthered naturally by the necessity of assembling under one hat the trunk traffic, which is still retained by A. T. & T. As chief supplier this company had had the

Western Electric Co., which was started in 1872 and during the later part of the 1870s was supplier to the Western Union, but finally allied itself entirely with its big customer A. T. & T. The direction both of commercial and technical developments has always remained with A. T. & T.

Great Britain

Bell's telephone aroused great interest in Britain immediately on its appearance. Edison's microphone design also was soon known in the country and shortly afterwards there were formed two companies, one for the exploitation of the Bell design and one an Edison company. In 1880 the companies joined up and amalgamated into the United Telephone Company.

In England, however, the state had a monopoly of telegraph business and took legal action against the company. The question was settled in 1881 by the company for a certain royalty, which was high, obtaining concession for local telephone business. In the same year the state (General Post Office) started similar business but while the private networks increased their number of subscribers rapidly the G. P. O. had but small success. When the demand for trunk traffic became apparent the state in 1884 had to begin the construction of trunk lines and continued with it. Shortly afterwards the company obtained concessions also for the building of such lines. Development after that was rapid. The United Telephone Company and other undertakings were merged in 1889 into The National Telephone Company which from then was the leading telephone undertaking.

Many people, however, considered that private interests had gained a position too much resembling a monopoly. Some years later, when the question was up in Parliament, it was decided that the state should more strongly operate its competition, previously rather weak, and that concessions should also be granted to local authorities. In 1889 G. P. O. was voted a considerable amount to enable it to open a competing exchange in London, and by hindering the company as far as possible in constructing its lines the relations between the state and the company became more and more strained. Finally when the company's concession expired in 1911 its property was taken over by the state which from then was alone in carrying on telephone business in Britain. The development of telephone business in Britain proceeded, except for the participation of the state, along lines similar to that in America. As regards the general spread of the telephone England cannot be compared with the pioneer country.

France

From the very beginning in France the telephone was declared to be a state monopoly. But, there also, private undertakings obtained at an early date concessions against high royalty. The French state, however, began its own business in the domain in 1882 and the private undertakings were taken over in 1887, after which the state alone had hand of all telephone business. In respect of the spread of the telephone France is not in the first rank.

Germany

Germany was the only one of the leading countries of Europe as regards the telephone where the business was taken in hand in its entirety by the state from the beginning. The postmaster-general *Stephan* recognized its value and introduced the telephone in all the large post offices which were without telegraph communication, so that in Germany there were by 1880 several thousand telephone instruments in service.

Bell had not taken out patents in Germany and the farsighted firm Siemens & Halske took up the manufacture of telephone equipments and made to a large extent its own improved designs. It is true that both home and American businessmen had tried to get concessions but Stephan carried through the state monopoly and Reichspostamt began to accept subscribers in 1880. The development of the local networks did not proceed so rapidly and the trunk traffic did not attain any great extent until the middle of the 1880s. Since then, however, the telephone has become ever more widely distributed.

Owing to the thorough research work carried on in Germany in this domain and the great development of German industry it has been mainly German designs that have been used in Germany. These have moreover been considerably distributed in Europe generally. As regards subscriber density in Europe only a few countries can show better figures than Germany.

Denmark

The first development of telephone in Denmark displays a picture similar to that of Britain. The absence of legal provisions allowed of private enterprise right up to 1889, when the state carried through its telephone monopoly. Concessions for telephone operation, however, were granted for local areas and these are still in force. Among the large telephone undertakings are chiefly to be noted the Copenhagen Telephone Society which serves the whole of Zealand, the company for Jutland and one for Fyen. The state runs the countrywide trunk network and has also connected a number of its own subscribers to it.

In regard to density of the telephone Denmark has a leading position. The number of subscribers per square kilometre is the greatest in Europe. The number of instruments per thousand inhabitants is also very large, but in this respect Denmark has for many years been surpassed by Sweden.

Norway

In Norway the state obtained in 1881 the sole right of telephone business, but with the important exception that, in towns or hundreds, private persons might also carry on such business. The local, municipal or private undertakings, which started at an early stage, soon began to feel an ever increasing need for joint traffic with each other and the Government at one time and another granted concessions for long distance circuits. The question of trunk traffic proved to be a difficult problem. The solution arrived at was that the state in conformity with decision of the Stortinget in 1896 bought up the private trunk lines and from then on took charge of long distance traffic. At the same time the Norwegian state also began to carry on local telephone business. Gradually more and more local plants have been taken over by the state.

Interest in telephone questions has been large and widespread in Norway and has contributed to a telephone density remarkably great, when the natural and population conditions of the country are taken into account. Thus Norway takes third place among European countries after Sweden and Denmark.

Development of The Swedish Telephone Network

Finally, after this general survey, I shall turn to the development of the Swedish telephone network with some reference to technical advances as well.

The fact that in Sweden no state monopoly for telegraph and telephone business existed at the beginning or was imposed by legislation has formed the basis of the development described below.

The First Telephones

The first time a telephone was exhibited in Sweden was in August 1877, when a Norwegian engineer *Hopstock* demonstrated an installation between the Grand Hôtel and the telegraph office in Stockholm. The same year a number of Bell's hand telephones were imported and by the beginning of the next year there were two telephone lines in Stockholm, one between H. T. Cedergren's shop and his residence at Drottninggatan and one between the gasworks and the gasometer on Vasagatan. During the first part of 1878, 23 more telephone circuits had been set up in the city. Bell's telephone was then employed as transmitter and receiver.

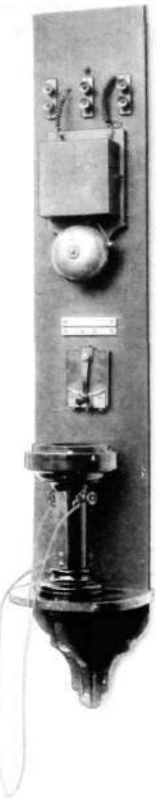


Fig. 7 X 4433

Telephone instrument, as used by H T Cedergren in 1878

The initiative for the laying of a real telephone network by which the telephone should be of public utility was taken in 1879 by three telegraph commissaries in Stockholm, Messrs. *Lybeck*, *Bratt* and *Recin*, whose application resulted in statements by both the Telegraph Administration and the office of the City Governor that there was nothing to prevent a telephone plant in Stockholm being laid. The above named gentlemen formed in 1880 the Stockholm Telephone Company. They turned, however, to the Bell Company in America for the purchase of instruments. That company, which itself wanted to run such plants, took over the Stockholm Company and the newly established Stockholm Bell Telephone Company in the autumn of 1880 opened Sweden's first telephone exchange in Stockholm on Vesterlånggatan. There were then connected 121 subscribers. Sub-exchanges were shortly afterwards opened in the south and north districts of the city and in the environs.

The Bell Company had plans for constructing telephone networks in a number of other Swedish towns, but only the networks in Gothenburg, Malmö and Sundsvall were constructed under this company's management in 1881.

On the other hand, in that year private telephone associations constructed networks at Norrköping, Gefle, Örebro, Eskilstuna, Västerås and Enköping. The Bell Company employed telephone instruments of the Bell-Blake type and the possibility for purely Swedish enterprise to execute telephone plants had by this time been created by L M Ericsson. He had been employed at A. H. Öller's workshop, referred to above, which manufactured telegraph instruments and other electrical equipment. Ericsson began his own business on 1st April 1876. When he learned about the telephone he carried out experiments with it and by 1878 he could make instruments himself and sell them on a small scale. His make proved to be equal and in many cases superior to foreign instruments. The Gefle telephone plant was the first to use Ericsson's make exclusively and was later followed in this by other telephone societies of the country. The early device with the receiver used also as transmitter had then been discarded and microphones of Blake's type had gained ground. The microphone design worked out by Ericsson, like that of the Bell Company, was of Blake model, but its extremely good facility for accurate adjustment of the carbon-platinum contact made it so efficient that for a long time afterwards it dominated the Swedish market. The Telegraph

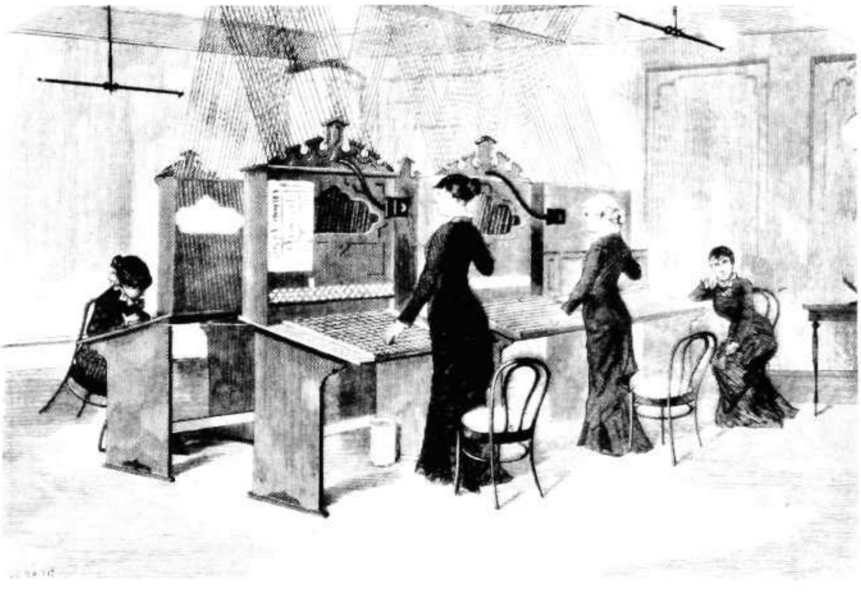


Fig. 8 X 6192

The Bell Company's first exchange

after a drawing by Victor Andrén

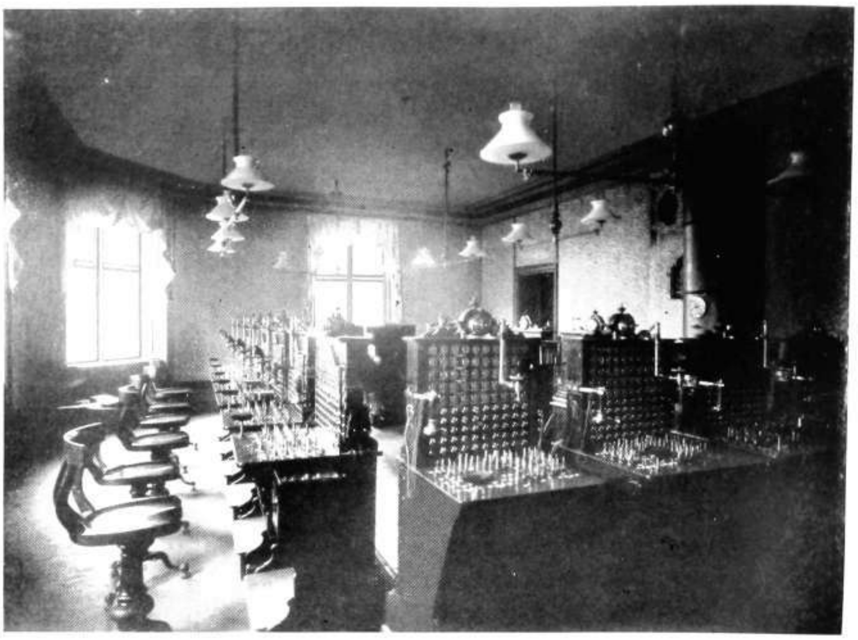


Fig. 9 X 6197
Allmänna's first exchange at Oxtorget in Stockholm 1883

Administration to begin with took up a watching attitude towards the new means of communication and made no objection when concessions for the above mentioned plants were applied for.

It was only in 1881, when these undertakings had attained such an extent that their activities might have an adverse effect on the telegraph business, that the Telegraph Administration asked for and obtained authority to, as it was put, »facilitate, by the laying down of telephone lines, telegraphic communication in those places that may be in need of it.» Consideration for the telegraph was undoubtedly the main interest of the Board of Telegraphs but recognition of the telephone as independent means of communication was to be found in measures by the board the same year to provide telephone communication between the ministries of state and the central administrative offices. The switchboard was set up in the central telegraph office at Stockholm and the plant when coupled up comprised 32 instruments which could also be linked with the private network. In accordance with the above authority, there were constructed in the years following a number of connections from telegraph offices to iron works, saw mills and large estates, which connections often were of considerable length, some of them as much as 50 km. When, later on, a number of such lines were connected to one telegraph section, the subscribers could begin to have calls with each other and this was the origin of the Telegraph Administration's local network outside the capital.

Some of these subscriber lines were also linked with the private network of the locality via the telegraph office. In many cases there was opened in rural districts also joint traffic between the Telegraph Administration and the telephone societies. The high subscription rate of the Bell Company undoubtedly contributed to the success of the telephone societies which were formed and operated without any idea of financial gain, and the subscription policy of that company also led to the establishment in Stockholm of another undertaking which in the course of time was to take precedence over the Bell Company.

Stockholm's Allmänna Telefonaktiebolag

The engineer H. T. Cedergren, who was responsible for the installation of one of the first telephone circuits in the country and later was a subscriber of the Bell Company, pointed out to the company's management that lowering of the charges would lead to increased expansion of the business. When he was not listened to, he entered into relations with L M Ericsson and came to an agreement with him for the supply of telephone equipment. He was then, after careful estimates, ready — despite doubts expressed in many quarters — to establish *Stockholm's Allmänna Telefonaktiebolag*, which was formed on 13th April 1883. In the same year in October »Allmänna's» first telephone exchange was opened at Oxtorget in Stockholm. Cedergren's measure of reducing the rates from the 160—280 kr. applied by the Bell Company to 100 kr. for all subscribers pointed the way by which Sweden was to become one of the foremost telephone countries of the world.

Provincial Networks

The Telegraph Administration in 1882 constructed telephone networks in Härnösand and Uddevalla, the first state networks outside Stockholm. In the beginning of 1883 the administration purchased the Bell Company's network in Malmö and in the following years extended this plant in Scania to Lund, Eslöv, Trelleborg and Landskrona. In addition a number of smaller networks or call offices were established in the regions of Bohuslän, Bergslagen and Norrland. The national telephone's network in Scania was later developed to comprise the whole province.

Alongside these developments there had taken place throughout the country great expansion of the activities of the telephone societies. Thus the number of societies, amounting to six in 1881, had by 1884 reached about fifty, an increase which was to continue.

Instruments and Switchboards

The material employed by the Bell Company in this period was entirely of foreign make. The Allmänna Company on the other hand had used nothing but instruments and switchboards of L M Ericsson's manufacture and the same was the case with the Telegraph Administration and the telephone societies.

In the Ericsson instrument there was used the improved Blakemicrophone referred to above and a receiver of modified Bell type. The telephone switchboards to begin with were made with metal guides fitted on a board, but Ericsson very soon introduced jacks and connecting cords with plugs, thus facilitating the work of the operators and reducing the space required. These switchboards were made for 50 subscribers. As the number of subscribers grew, switchboards had to be set up side by side and junction lines arranged between them. To avoid having excessively large exchanges and to keep down the length of the subscriber lines both the Stockholm companies in their early years established branch exchanges in the various sections of the city. The difficulty in dealing with operation, however, grew with the increase of subscribers and the large numbers of switchboards required. In each exchange the operators had to call out the wanted subscriber's names and numbers to each other and conditions finally became unbearable. However, the engineer *Schribner* in Chicago had as early as 1879 designed a multiple switchboard in whick every subscriber line was accessible to all the operators. When Cedergren and Ericsson learned of the system, the latter designed the first Swedish multiple switchboard and this was installed in Allmänna's exchanges. The company, whose business was constantly expanding, could then plan the construction of large exchanges with good operating facilities and in July 1887 there was officially opened at Malmskillnadsgatan in Stockholm an exchange for 7 000 subscribers.

As regards instruments, another design should not be ignored in this connection. Even when Cedergren in 1883 was making his first appeal for subscriptions, to those subscribers who were content with a common or party line he could offer automatic switching instruments invented by him and Ericsson. These were available for 2 or 5 lines respectively and subscription for party line meant even lower charge than the 100 kr. applied in competition with the Bell Company.

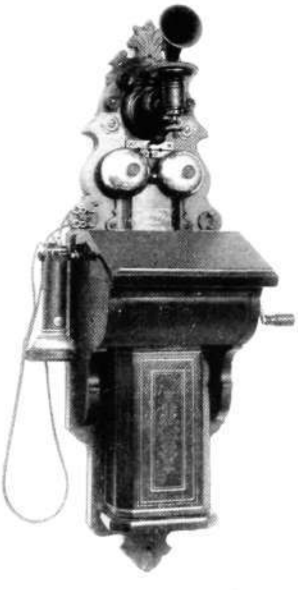


Fig. 10 X 4430

Telephone instrument with redesigned Blake microphone, manufactured by L M Ericsson

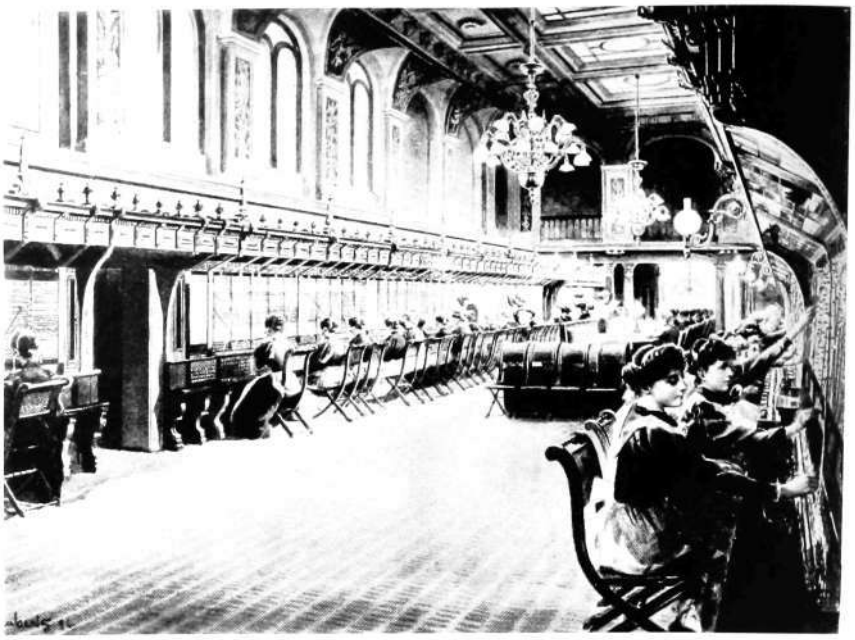


Fig. 11 X 6199
Allmänna's telephone exchange at Malmskillnadsgatan in 1887

Competition Between the Telephone Undertakings

The competition that took place from 1883 between Allmänna and Bell resulted in victory for Allmänna. The growth in the number of subscribers to the Bell exchanges fell off, despite a certain reduction of charges, and ceased in 1887 after which it was replaced for many years by decrease. This circumstance gave rise to negotiations between the Telegraph Administration and the Bell Company for the sale of the company's telephone plants in Stockholm and Gothenburg. In 1888 the Telegraph Administation purchased the Gothenburg network but as regards the plants in Stockholm the matter dropped. Instead, Cedergren that year bought up the majority of shares in the Bell Company, which three years later was merged into the Allmänna Company.

In Cedergren, Allmänna had a chief with both initiative and force of action and the Board of Telegraphs found ever greater reason to consider the question whether the state or private enterprise should in the future provide the country with telephones and arrange communications between different centres and regions. From the beginning — as stated above — the Telegraph Administration had held a watching brief. Nevertheless attempts were made more and more to limit and regulate private activities, to a certain degree by laying down telephone lines and networks, but to a greater extent by decrees and administrative measures.

In 1883 a royal decree was issued which included prohibition for companies or private persons without royal permission setting up telephone circuits on crown lands or on the ground of public roads or railways. Tightening and clarifying of this decree called for by the Board were not supported by the Riksdag nor was there accepted a proposition submitted by the Government in 1888 for telephone tax, though even then fears had been expressed in the Riksdag that the Allmänna Company might attain far too great an influence.

By this time the company, which then as regards telephones dominated Stockholm and its environs, had arranged communications with several provincial towns such as Södertälje, Nyköping, Enköping, Uppsala, Norrtälje and Västerås. Cedergren in February 1888 had even applied for permission to construct telephone lines from Stockholm to Örebro, Gothenburg, Malmö and Sundsvall, making use of the ground bordering roads.

That was for the state the deciding impulse which was to make the Board of Telegraphs change-over to a more positive form of competition. Cedergren's application was rejected but the Board of Telegraphs declared itself prepared to lay down not only the long distance line in question but any subsequently required, and the Government granted the requisite funds for the construction of the Stockholm—Gothenburg circuit. The work on this was begun in the autumn of 1888 and was completed the following year. Before the close of 1888 the Board of Telegraphs also submitted to the Government a plan for a national telephone network, comprising altogether over 2 700 km trunk lines. That was not all. In July 1889 the Board of Telegraphs invited those persons who wished to avail themselves of the facility of long distance calls to become subscribers at the exchanges of the administration and that same year a new trunk telephone exchange was ready for service in Stockholm. The Stockholm—Malmö circuit was opened in 1890.

In the beginning of that year a new director-general came to the Telegraph Administration, an engineer and organizer of unusual quality, *Erik Storckenfeldt*.

At this time the National Telephone had about 5 000 instruments, Allmänna and Bell together about 7 000 and other private networks something over 8 000 instruments. Storckenfeldt's first measures were devoted to technical improvement and rationalisation of the telephone service. More up-to-date instruments and switchboards were put in, still of L M Ericsson's make, uniform methods for the establishment of calls were worked out. In the early 1890s there was also constructed a large number of new trunk lines and from the Allmänna Company were purchased its lines to Västerås and Nyköping as well as the line constructed the previous year to Norrköping.

After some negotiations there was reached in 1891 the agreement with Allmänna Company, of great importance for further developments, that the sphere of activity of Allmänna should be restricted to a circle with 70 km radius and with the Great Square of Stockholm as centre. This meant that Allmänna had its area restricted but also that it could concentrate its operation, which the company did successfully. The Telegraph Administration, which retained its own network in Stockholm, had as regards the rest of the country liberated itself from its energetic competitor and now began to buy in more and more of the private provincial and local network. In certain places these efforts encountered strong opposition and the administration therefore in 1893 began to construct its own plants in direct competition with the local networks.

During this period the question of joint traffic between state and private networks, which naturally was of great interest to the public, became more pressing. In Stockholm joint traffic with the Bell Company had been arranged even when the Telegraph Administration's first switchboard was put into service in 1881 and with Allmänna also in 1884. When the Telegraph Administration became sole owner of the trunk lines the question of joint traffic took on a new aspect. Naturally the administration was not disposed to give subscribers in private networks as cheap access to the trunk lines as the National subscribers, nor would the Allmänna Company without a struggle let the relatively few National subscribers in Stockholm have the benefit of free access to the company's considerably greater number of subscribers, especially as annual subscriptions were lower for National than for Allmänna. The question was also dependent on whether the subscriber lines were double-wire or not. An agreement in which it was fixed that joint traffic charges, different for local and trunk calls, should be debited to the subscribers, was reached in July 1890 and joint traffic then proceeded up to 1st July 1903.

It would take up far too much space to deal in detail with the competition between the Telegraph Administration and the private telephone undertakings, which especially as regards the National-Allmänna struggle in Stockholm presents interesting points and was followed by the press and the public with a great interest easily to be understood. The weapons employed by the two parties were lowered rates and other more temporary benefits but also technical improvements, all designed to attract new subscribers.

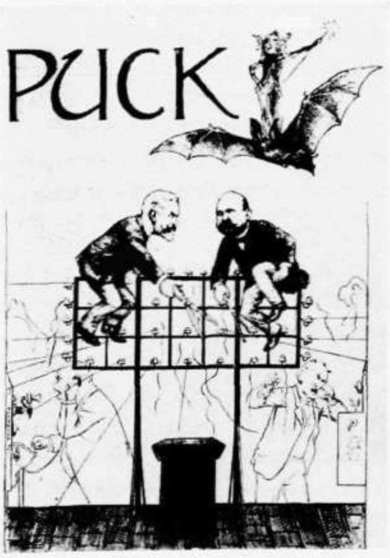


Fig. 12 X 4423
Director general Sahlin and Director Cedergren cut off joint traffic
Cartoon from Puck 1903

Nationalisation of The Telephone

For the public in the 70 km area the competition obviously constituted an advantage, but it was extremely vexing for the operators of the networks and the natural consequence was the idea of an amalgamation by state purchase of the Allmänna Company's plant. At the close of 1901 the first purchase agreement preliminarily approved by the Board of Telegraphs and the Company was ready. After foreign experts called in had approved the agreement, the Government presented a bill containing it to the Riksdag of 1902, which, however rejected it.

Storckenfeldt had more success in his measures to transfer the networks out in the country to state ownership. Both the telephone associations and private companies had constructed local networks in the provinces, the number of instruments in which exceeded the National telephone in 1890. The telephone associations were a kind of cooperative undertakings with very inexpensive administration. The premises were the simplest possible and the operators, who often had the switchboard work as a sideline, were poorly paid. The annual charges therefore were not burdensome, but the maintenance, as regards the exchanges carried out by some selfinstructed person resident on the spot and as regards lines by the subscribers themselves, was most often unsatisfactory. To augment the value of the telephone the associations had begun to form telephone federations and to build circuits between the local networks.

Both the subscriber lines and the junction circuits between places were single-wire. The quality of speech, on which only modest demands were imposed, on the longer lines was far too poor and as the annual charges did not allow of renewals or improvements, the situation began to be troublesome for those who required surer and quicker call facilities. The Telegraph Administration which had begun to construct good trunk lines had very good quality to offer but could despite decreasing the annual charge, usually to 50 kronor, exercise no direct price competition. Nevertheless Storckenfeldt opened negotiations. Even before then, isolated purchases had been made but the landslide began in 1891. Among the networks then acquired may be mentioned the Haglind provincial network in Östergötland, the city networks of Norrköping and Sundsvall as well as several networks affiliated to the Örebro telephone federation. These purchases comprised in all 2 000 instruments. The following year there was acquired the network in Gävle town and the rural district around, and buying continued. The Allmänna telephone society's network in Gothenburg, where the Telegraph Administration had owned the former network of the Bell Company since 1888, was taken over in 1896. By 1894 the national network had more instruments connected than all the private companies together. Leaving aside the 70 km area of Stockholm, the Telegraph Administration in 1889 owned but 28 % of the instruments in the country. At Storckenfeldt's death in 1902 the figure was 97 %. The increase shows the energy and success displayed by this notable man in carrying out the task he had imposed on himself.

The curves of Fig. 13 show the numbers of instruments during years gone by in Sweden. From these it will be seen that the Telegraph Administration during the years 1902—1918 had approximately 2/3 of the instruments in the whole country including the Stockholm network. The remaining third belonged for the most part to Allmänna — from 1907 known as Stockholm Telephones Limited (S.T.). The private networks in the provinces were then insignificant in extent. The increase in number of instruments in these networks to be noted in the figures from 1904 is due to inclusion in them also of the state railways and private railways service instruments, which in 1944 constituted about 9/10 of the private network instruments. Both the National and the Allmänna (S.T.) had in the whole time from 1912 increased their instruments, but the proportion 2 : 1 continued practically unchanged, which means that the Stockholm Telephones Ltd. had in the 70 km area the greater progress. A proposal in 1904 to divide this area up in such a way that the

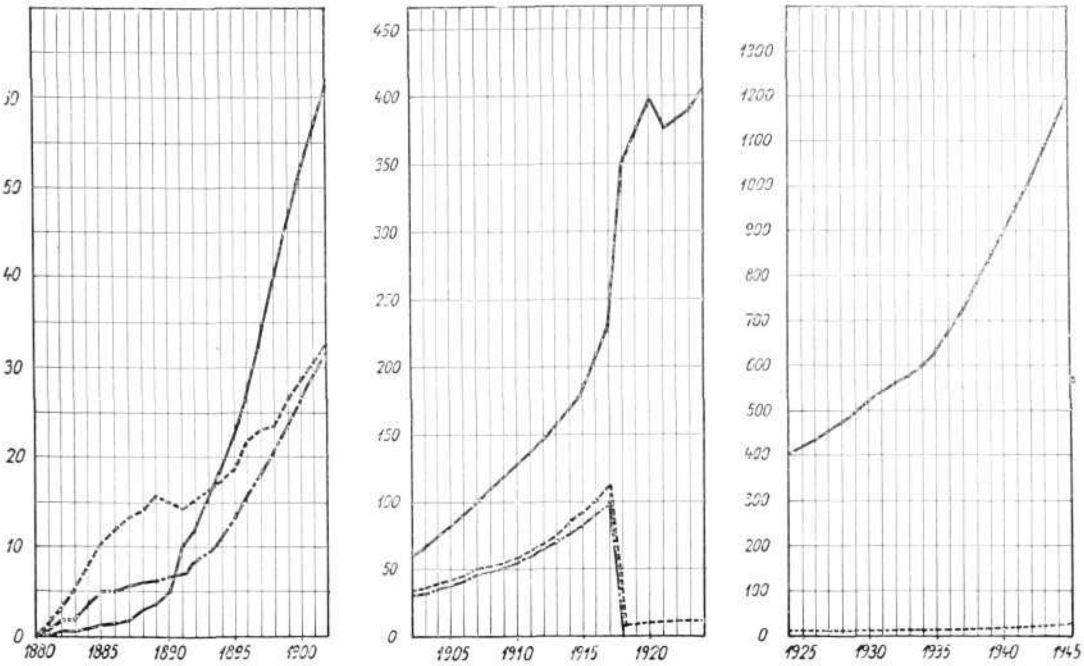


Fig. 13 X 7411
Diagrams showing the number of telephone instruments in Sweden for the years 1880—1945

———— in the Telegraph Administration networks
- - - - - - - - in all private networks
—·—·— in the Stockholm Companys' network

Telegraph Administration would take over Allmänna's network south of Norrström and pay a certain compensation to the company while the latter would take over the National Telephone's local network north of this boundary a year later to buy the whole network of the company for about 16.5 millions did not gain the acceptance of the Riksdag. The same fate met a proposal kronor. It was only in the Riksdag of 1918 that the question was settled. The purchase price then was about 46.7 millions and in July of that year Stockholm Telephones Ltd. handed over to the Telegraph Administration the whole of its telephone plant in Stockholm and a radius of 70 km.

Technical Developments

It has been stated that both the Allmänna Company and the National telephone continued to make technical improvements. In regard to the telephone instruments the Ericsson instruments with their special microphone design were for many years among the foremost. Later when the carbon granule microphone became known a change-over to this was also made in Sweden. The new instruments were made by L M Ericsson and from 1891, when they started their own factory, by the Telegraph Administration also.

An important advance is represented by the combining of transmitter and receiver to one unit, the handset. To make his work more comfortable one of the men at the Allmänna Company had hit on the idea of tying a microphone to a receiver. His foreman took up the idea and L M Ericsson developed it. The first model and a number of transition forms have been preserved so it is possible to follow the development up to the types now employed in Sweden. In other countries too the handset is now generally used.

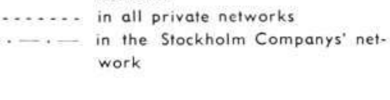


Fig. 14 X 4432
L M Ericsson table instrument with handset, 1895

As regards station equipments it is only possible to mention a few designs here. Allmänna introduced in its larger exchanges desks with multiples for a large number of subscribers. The largest multiple of its time was arranged in the demonstration switchboard at the Stockholm 1897 exhibition, with 20 000 numbers. Later Allmänna installed in its new exchanges in Stockholm multiples of up to 36 000 numbers, but the maximum capacity of the desks was reckoned for no fewer than 60 000. Desks with similar multiple fields were supplied also to Moscow and Warsaw. Space had to be saved in the switchboard panels and 100 jacks therefore took up only 36 cm² of space.

Engineer *J. A. Avén* of the Telegraph Administration designed at the opening of the century a distribution system for the national telephone exchanges in

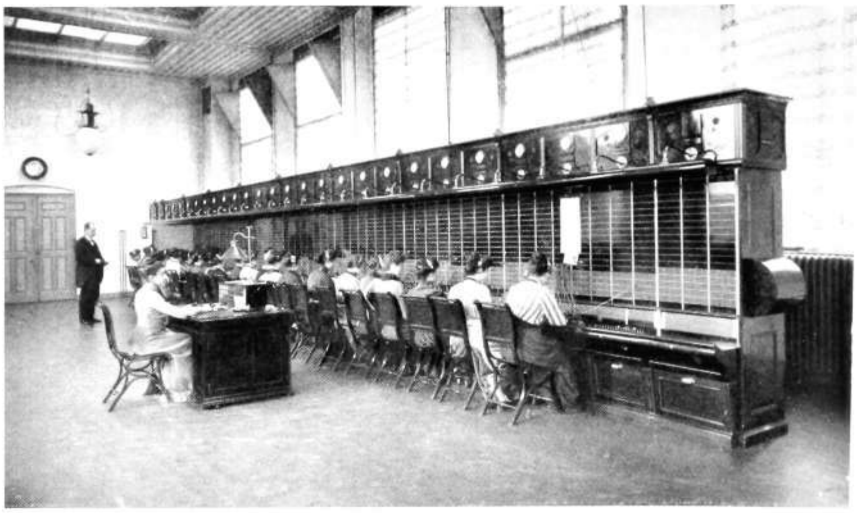


Fig. 15 X 6198
L M Ericsson's first C.B. exchange, supplied to the Hague in 1903

Stockholm and Gothenburg, which had the call indicators housed in special desks where »dumb» operators connected the calling subscribers by connecting cords to multiple boards where another operator completed the connection. In this way the staff were better utilized and the times of answering were shorter and particularly more even.

Signal lamps instead of drop indicators were introduced by Allmänna as early as 1897. Lamp signals later became general, especially when change-over was made to the central battery system, which after impulses from abroad was developed by both L M Ericsson and the Telegraph Administration.

L M Ericsson's first C.B. exchange was put in service at the Hague in 1903 and the first Swedish Telegraph Administration exchange of this type was supplied by Ericsson in 1909. For smaller exchanges and for private branch exchanges new improved switchboard types were produced in the following years, many of which are still in service. A problem which it was found difficult to surmount in the large cities was constituted by the traffic that had to be established between the different sub-exchanges. Many methods were tried and automatic selection of disengaged trunk line and disengaged operator was introduced in Stockholm shortly after 1918, when the national telephone took over the subscribers of the private networks and introduced full joint traffic, before the networks and exchanges of the different undertakings could be merged. Even later, trouble and cost was caused by the junction traffic which required at least two operators to complete the connection, and this only disappeared with the automatisation of the whole Stockholm network.

Automatisation

The idea of entirely replacing manual operation by automatic and thereby escaping the expense of operators had arisen at an early stage. In *principle* the problem is simple, consisting in the replacement of the manual telephone switchboard by connecting devices, known as selectors, set by remote operation, which as is known is executed by means of a dial. The first known idea for an automatic telephone switchboard was the subject of patent application in America in 1879. The first automatic telephone switchboard, which had a capacity of 100 numbers, was installed at La Porte, Indiana, in 1892. These selectors were of a type called Strowger selectors, after the inventor. The Strowger system made great progress in America and the first exchange for 10 000 subscribers was put into operation at Chicago in 1903. Gradually automatic exchanges began to become more general in Europe as well, Germany getting its first trial exchange in 1908.

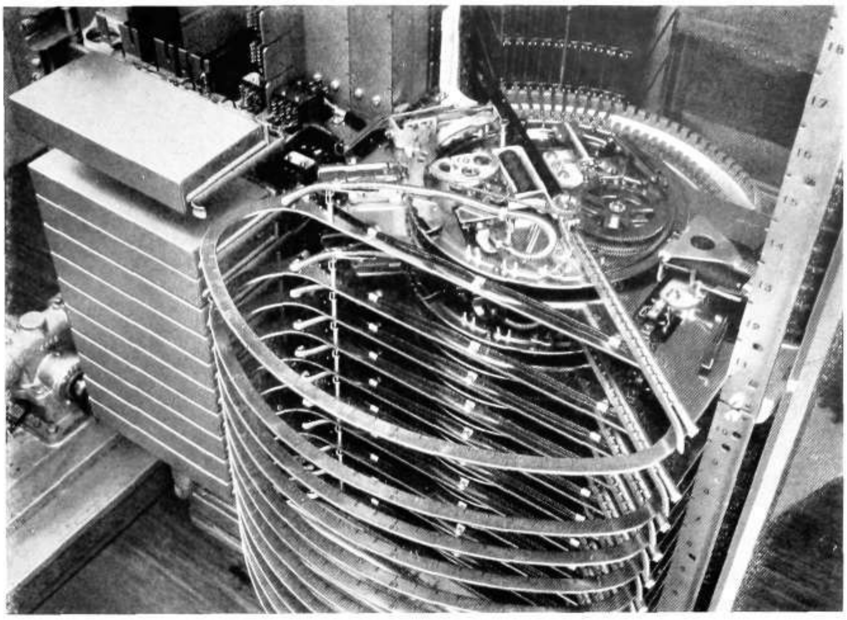


Fig. 16 X 6195
Selector in the Hultman-Ericsson automatic telephone system with 500-line selectors

In Sweden, as mentioned earlier, Cedergren and Ericsson had as early as 1882 designed small automatic switchboards, the selectors of which were operated over a circuit by an operator at the manual exchange. In the later part of the 1890s *G. A. Betulander* designed small fully automatic switchboards and some exchanges were equipped with them. These Swedish contributions, however, were merely in the nature of trials. After 1910 the Telegraph Administration set itself seriously to study the problem. A trial plant with rotary selectors was purchased in America and set up at Landskrona in 1915. War then stopped business with foreign countries but L M Ericsson, who had begun his experiments in 1913, had a trial exchange completed in 1918. The Hultman-Ericsson machine-driven system with 500-line selectors was ready for delivery a couple of years later and as it proved to be more satisfactory than the foreign systems the Board of Telegraphs decided that it should be introduced in Stockholm and Gothenburg. The first exchanges of this type were at Rotterdam, Hamar and Kristiansund these being completed in 1923, and Norra Vasa in Stockholm which was opened for traffic in January 1924. L M Ericsson has made most of the Telegraph Administration's large exchanges as also a great number of foreign ones on this system.

Around 1915 the Telegraph Administration began to interest itself in another type of selector, known as crossbar selector, which consists of relays with armatures intersecting. Plants with these selectors were designed by Betulander, H. Olson and they were made in the administration's workshops. The first exchange of this type was opened at Sundsvall in 1926. In addition, the Malmö exchange and some other main exchanges are fitted with crossbar selectors, though these have found their greatest utility for small exchanges. L M Ericsson also has taken up the making of crossbar selectors of improved construction, worked out in conjunction with the Telegraph Administration, and the administration will be adopting these. The concern has moreover developed a modification of the 500-line selector, smaller and adapted for small exchanges, which has been given the name of XY-selector and is direct driven like the Strowger selector. The first of these were ready for delivery in 1938. The XY-selector is chiefly employed in inter-communication telephone plants.

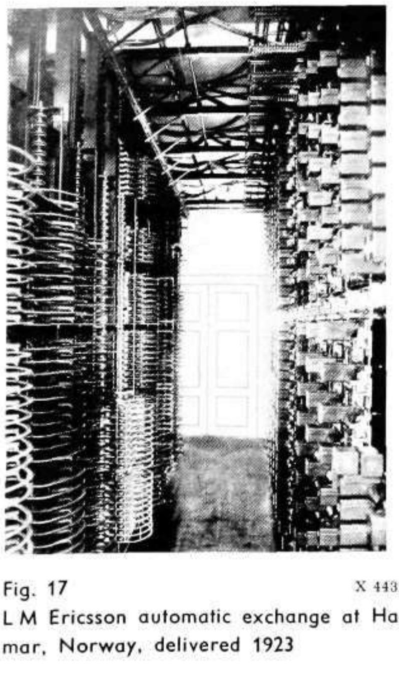


Fig. 17 X 4431
L M Ericsson automatic exchange at Hamar, Norway, delivered 1923

From 1920 automatisation began in Sweden, the start being made with the large main exchanges as the financial gain with these is comparatively large. In the last decade, however, side by side with the large exchanges, automatisation has also been extended to medium-sized exchanges and to a number of

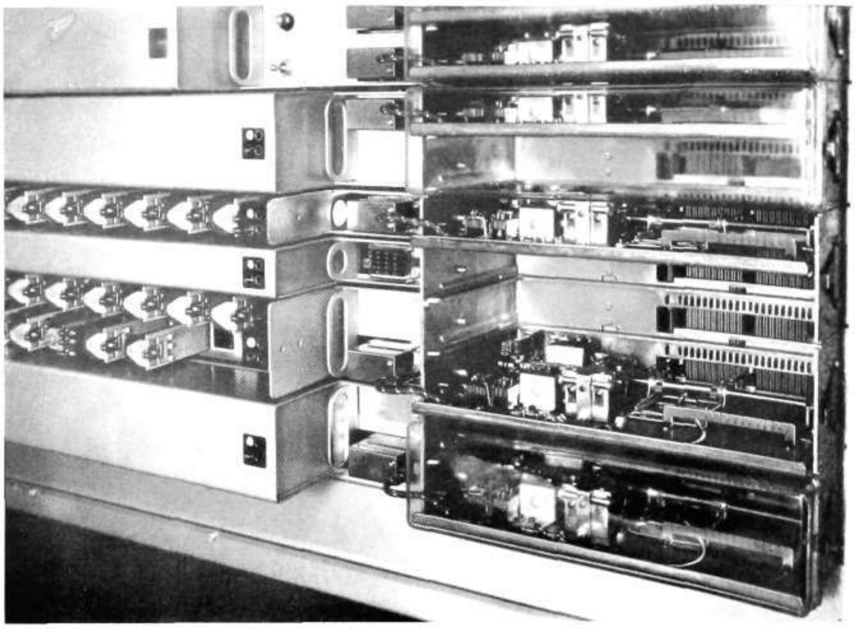


Fig. 18 X 6194
Section of rack with L M Ericsson's XY-selector

small ones. While in 1934 only 12 exchanges were provided with automatic switchboards, by 1945 over 1 000 exchanges, including some 30 main exchanges, were automatised. The number of instruments connected to automatic exchanges is approximately 650 000, representing about 56 % of the instruments in the country. More than ½ a million of these instruments are connected to L M Ericsson switchboards.

Lines

Open-wire Lines

The first telegraph circuits of any length were constructed as open-wire aerial lines on poles or wall brackets. The insulators were made of gutta-percha, a material which when exposed to the air and particularly to sunlight dried and became brittle. Trials were made with various materials and porcelain has finally been adopted. The insulators are now made with domes, usually two, to increase the insulation resistance.

It may be surprising to learn that the poles put up in Sweden during the 1850s had not a longer life than 5 years, sometimes only 2 or 3 years. Evidently this was due to the fact that they had been felled in the early summer. After impregnation of the poles had been introduced, a durability of some 30 years was finally obtained by the employment of creosote-oil. Lately good results have also been obtained with arsenic preparations, but no figures for durability are available yet.

The telegraph lines in Sweden were constructed up to about 1890 solely of iron wire 4—5 mm diameter. The first telephone lines were made in the same way as the telegraph lines, though mostly with thinner wire. In the larger networks use was made of 1 mm bronze wire. For the longer telephone circuits it was soon found that copper wire must be used. Thus as early as 1885 the Allmänna Company built a copper line between Stockholm and Enköping.

It was also found that the sound transmission quality was very appreciably deteriorated by noises from the earth connection and by crosstalk from adjoining single-lines, so that the long lines at least had to be made double-wire. The two iron lines laid by the Telegraph Administration in 1883 between Malmö and Lund were the first double-lines in the country. The following year these were improved by transposition which counteracted crosstalk. Twisting of the wires, a method much better in this respect, was

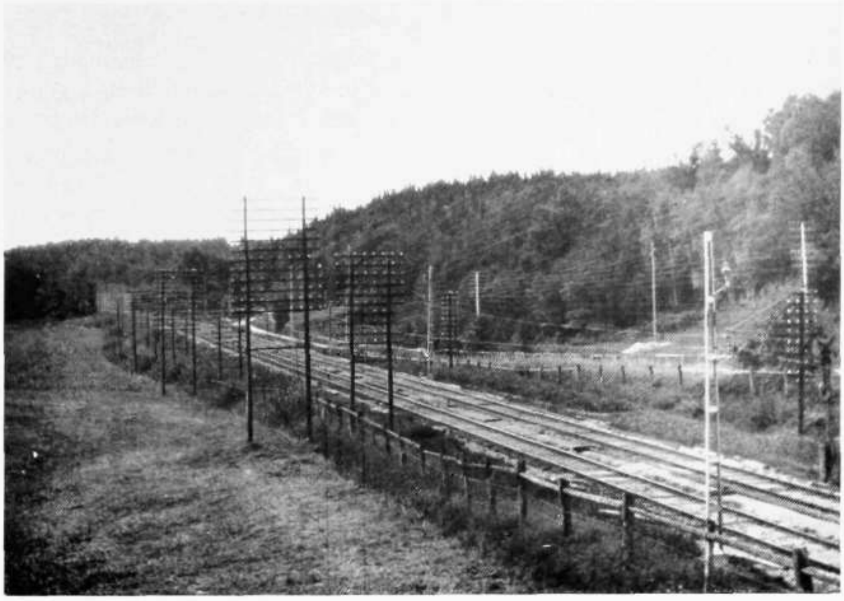


Fig. 19 X 6200
Pole lines along the Stockholm—Södertälje railway 1924
carrying about 280 wires

introduced im 1889 when setting up the copper lines between Stockholm and Gothenburg.

At this time all local networks in the country were single-wire. Today it is difficult to conceive how it was possible in the large towns to manage with the low quality these simple networks could offer. At the same time it must be remembered that there were not then any disturbing strong current lines and that the pretensions of the public are much greater today than they used to be. Nevertheless, towards 1890 the leading telephone undertakings realised clearly that doubling of the single networks would be necessary. The last local network made by the Telegraph Administration with single lines was constructed in 1889. After 1892 the Telegraph Administration accepted no new single-wire subscribers at its exchanges though those already existing were kept on for a time. The Allmänna Company too had in 1889 taken up the question of doubling the lines, but this work was dependent on permission from Stockholm city to use street ground for subterranean lines. The work of doubling, however, was begun in 1891 and was practically completed in 1893.

The private networks out in the provinces retained their single-wire and were doubled only as and when they were taken over by the Telegraph Administration.

After the area of activity of the Allmänna Company had been restricted in 1891 to the 70 km radius, all further extension of the long line network devolved on the Telegraph Administration. The administration continued to build both copper and iron lines at a rapid rate and at the beginning of the century all places of any importance in Sweden had call facilities with each other, with the exception that upper Norrland could not exchange calls at all with southern Sweden and only with difficulty could reach exchanges south of Sundsvall. In the last years of the previous century lines of 4.5 mm copper wire had been constructed from Stockholm to Gothenburg and to Malmö. Such circuits were laid between 1901—02 from Stockholm also to Sundsvall and Östersund as well as to Luleå. After about 6 000 km of 3 mm copper line had also been laid throughout the country, including Norrland, it was considered that satisfactory trunk traffic had been made possible for the whole kingdom. The development of the national network continued in similar manner in the next 20 years.

Local Cables

In the forming of the local networks after 1890 the new cable practice had led to great changes. With a number of telegraph lines in the middle of last century gutta-percha cables had been used also as underground cables. The gutta-percha was not suitable and a change to rubber as insulation material was made. When it became a question of the large number of lines in the telephone networks these cables chiefly on account of the great expense were not suitable. Even earlier both the Allmänna Company and the Telegraph Administration had considered the possibility of using telephone cables. Lead-sheathed cables, which began to be manufactured just before 1890, proved the best. To begin with the conductors in these were insulated with cotton yarn, but a change was soon made to paper as insulation material.

The changes in local cables since then have chiefly consisted in measures by which, without any deterioration of the electric properties of the cable, larger numbers of conductors could be got into the same cable section. The first lead cables were supplied to Sweden in 1889 from Germany and England. These countries were the chief suppliers up to 1910 when Sievert's cable works began to make lead-sheathed telephone cables. In 1890 the Telegraph Administration succeeded in getting permission from Stockholm city to lay underground cables along certain stretches, but conditions set up later by the city were considered unacceptable, so the laying of cable blocks was stopped and the network for some time to come had to be extended by aerial cables. The same hesitation regarding the terms of the city was felt by the Allmänna Company, whose first cable net therefore was aerial. Later both from Stockholm and from other towns acceptable terms could be obtained and in all towns and larger communities subterranean cable networks were extended.

The method of laying in ducts generally used in Sweden was worked out by *Axel Hultman*, then a telephone inspector, following a journey of inquiry to America in 1890. Hultman, however, did not apply the American methods, but made a design of his own, cement blocks with conduits for different numbers of cables. The number of cable conduits in such blocks have since varied between 2 and 48. Allmänna used blocks with up to 87 conduits.

Before dealing with the employment of telephone cables for long distance lines, mention should be made of some methods to ensure good sound transmission while at the same time keeping down the number of lines and the dimensions of the conduits.

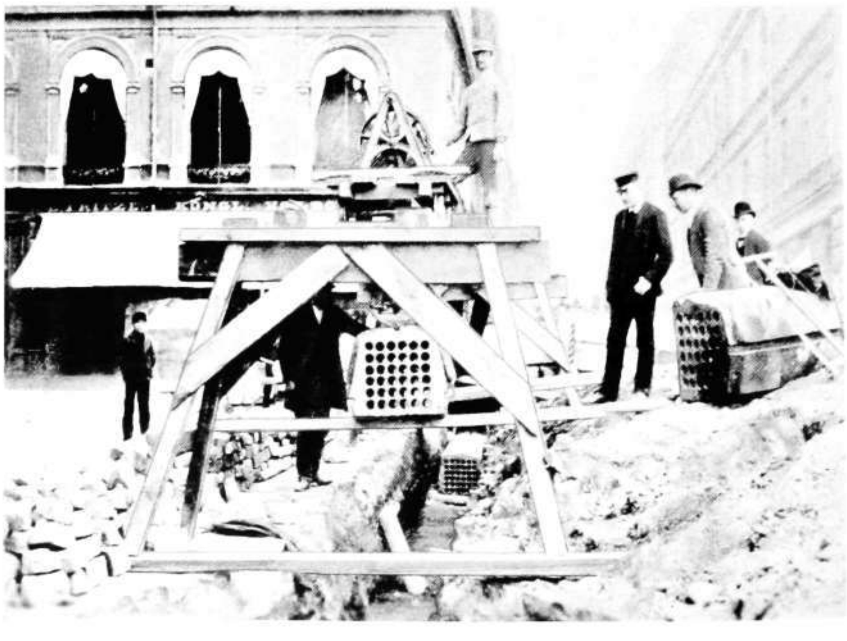


Fig. 20 X 6196
Laying of cable blocks in Stockholm about 1890

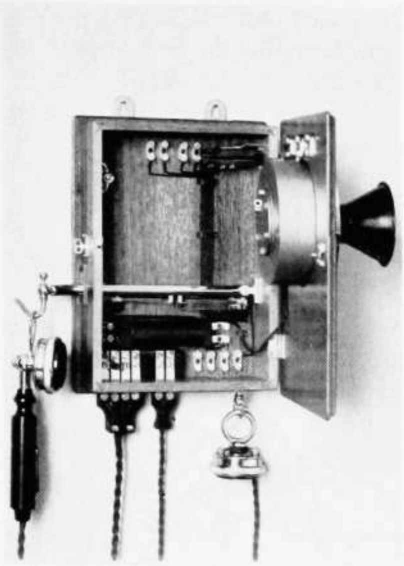


Fig. 21 X 4434
Egnér-Holmström's strong current microphone

Strong Current Microphone

First mention should be made of Egnér-Holmström's strong current microphone. The design aimed at increasing the amplitude of the outgoing speech current by making the current in the microphone circuit, and thus also the current variations, stronger than the ordinary microphone could produce. In test pieces there was attained an outgoing speech current some 30 times greater than normal, but for practical reasons a tenfold increase was not exceeded. L M Ericsson took up the manufacture and a hundred or so instruments were set up at the beginning of the century. Two circumstances were to limit the employment of the instrument. As is known the attenuation of speech increases in geometrical progression with the length of line. If it were possible with an ordinary microphone to talk satisfactorily over a section of, say, 3 000 km then, with the ten times more powerful strong current microphone, one would not be able to converse for a greater distance than about 5 000 km. Moreover the strong current caused great crosstalk to other lines. Therefore when the designers tried out a specially arranged circuit of 2 270 km between Stockholm and Paris the sound transmission in Germany, where the lines were not transposed, was so strong that the system could not be permitted there. Since the introduction of amplification of the speech currents at intermediate points on the line by telephone repeaters, the strong current microphone has lost its utility.

Phantoming

To enable two line pairs to convey three simultaneous conversations what is known as phantoming is employed. The phantom circuit is formed in the same way as is done in the telegraph transforming referred to earlier, by two circuits being joined up to make a double circuit. The two metallic physical circuits must in this case either be twisted or transposed so that both the pairs and the two wires in the same pair change place with each other according to a definite plan. Phantom circuits began to be used in Sweden towards the end of the century. In 1944 the Telegraph Administration had in its national and rural networks some 264 000 km bare-wire double lines. From these have been obtained about 86 500 km phantom circuits, representing an increase of circuits of app. 33 %.

Loading

The third method is loading. After *Heaviside* had at the end of the 18th century mathematically dealt with the electrical process with the conveyance of alternating current over lines, methods for counteracting the weakening of the sound of the voice in long lines were worked out by many investigators, among whom may be noted *Pupin*, *Breisig* and *Pleijel*. Pupin's name is associated with the method, loading, which in the present century has come into use in all telephone countries. The method consists of counteracting the attenuating effect which the capacity between the two wires in the lines has on speech, by inserting into the line self-induction coils. The first loading in Sweden was done in 1911 on a copper line between Örebro and Sundsvall according to instructions of Pleijel. Iron lines could also be used and the loading of bare-lines proceeded so rapidly that in ten years some 21 000 km national and rural lines were furnished with loading coils, thus providing considerable savings in line material. Nevertheless the inductive load introduced at points on the lines involved difficulties when telephone repeaters began to be used. Simultaneously leakances occurring on the lines had an adverse effect on the loaded speech circuits. At the beginning of the 1920s, with the introduction of telephone repeaters, bare loaded lines had reached the above maximum figure of 21 000 km and from then on so many lines were unloaded — or taken down — that the figure by 1931 had sunk to about 2 000. In 1941 the last loading coil was disconnected from the bare-line network.

The loading of cable lines, however, had then obtained much greater importance. As early as 1910 both the Telegraph Administration and the Stockholm Telephones Ltd. had begun to load cables between Stockholm and its suburbs. The Telegraph Administration, besides rural cables, also loaded lead-in cables to long lines to the more important trunk exchanges. Apart from trunk cables it may safely be reckoned that loading will be used more and more, in any case for rural cables of any great length.

Long Distance Telephony

The amplifier valve opened not only for radio technique but also for long distance telephony a new era. The American *de Forest* and the Austrian *Lieben* produced the first amplifier valves and the American *Langmuir* perfected the design. Edison was the first to indicate suitable coupling for a telephone repeater. The coupling now generally used was indicated by *W. C. Richards*, also an American. During the 1914—18 world war, amplifiers came into great use.

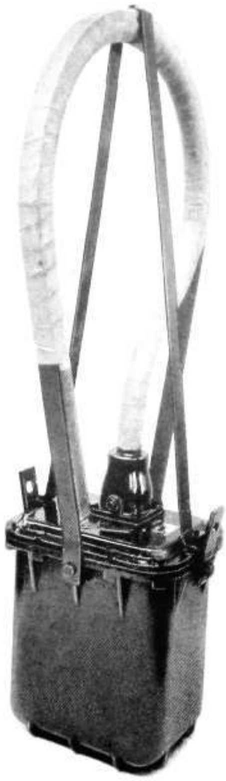


Fig. 22
Loading-coil pot
of L M Ericsson make

X 4427

The telephone repeaters allowed of the employment of cables even for long distances. In Sweden consideration was begun in 1918 of a Swedish trunk cable network and in 1920 the Board of Telegraphs ordered from Western Electric Co. in U. S. A. a cable plant Stockholm—Gothenburg, at the time the most up-to-date in Europe. Western Electric supplied cables, loading coil pots and repeater equipment and exercised technical supervision of the plant through their own engineers. The work, in other respects carried out by Swedes, was begun in the spring of 1921 and completed in the autumn of 1923. When the following year the Telegraph Administration proceeded with a cable Stockholm—Norrköping the repeater station equipment had been re-designed to Swedish patterns and only the repeaters themselves were imported. The cable was delivered in this case for the most part by Sievert's cable works, which had obtained a licence from the Western Electric, but the loading coil pots were still bought from that firm.

Now the Swedish trunk cable plants mainly use purely Swedish material. The cables are made by Sieverts while L M Ericsson supplies pots and repeaters.

The conductors in the cables are twisted on the Dieselhorst-Martin system. Two wires are twisted into a pair with different pitches, the pairs then being twisted into a quad. In this way there is achieved, after the capacitance unbalance on splicing has been smoothed out, high values for crosstalk attenua-

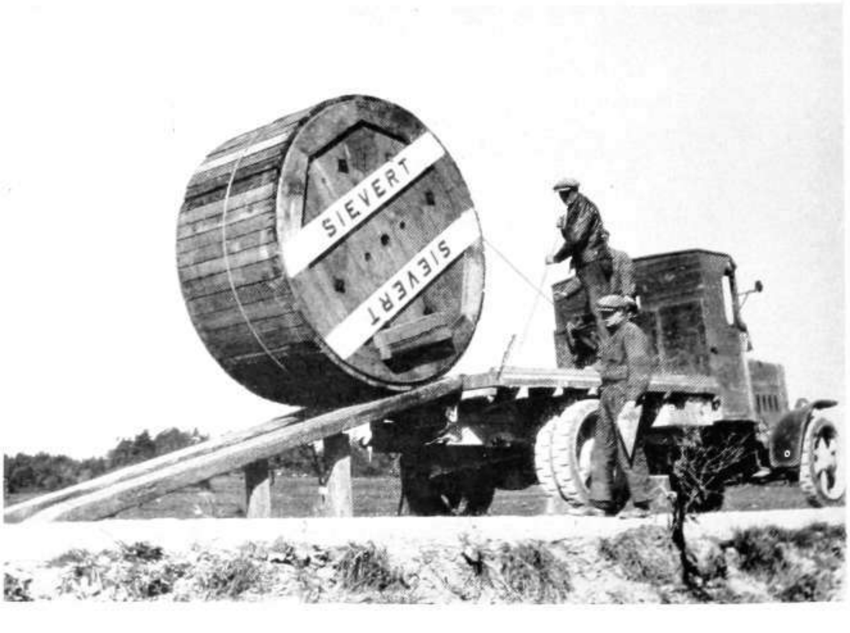


Fig. 23
Trunk cable drum

X 6201

tion between the speech circuits in the cable. The cables contain both 2-wire circuits when the speech is conveyed on the same line in both directions, and 4-wire circuits when 2 speech circuits are required for the conversation, one in each direction. In the last 14 years there had also been inserted in the cables special line pairs for wireless broadcast distribution. The loading has in the course of years been altered with the object of obtaining lines with higher cut-off frequency. On such lines it is possible to superimpose carrier frequencies in the 3 000—6 000 c/s band.

Carrier Frequency Systems

Carrier frequency telephony was first used on bare-wire lines, which have no equivalent to the cut-off frequency of the loaded lines. In the years 1921—22 a German two-channel carrier frequency system was installed on a Stockholm—Malmö line. Svenska Radiobolaget, which at the same time delivered a plant abroad, supplied one in 1923 for Örebro—Sundsvall and the following year for Stockholm—Umeå. This system operated with high cycles. It proved difficult, however, to link the high frequencies to the bare-wire lines used. The increase in attenuation which hoarfrost deposit on the wires caused also contributed to a change-over to single-channel systems with the highest carrier frequency around 10 000 c/s. Such systems allow of the utilisation both of physical and phantom circuits as well as of several lines laid in one and the same pole line. The device has been of great value, among other things in avoiding the construction of new bare-wire lines pending the cablification. When later the section is cablified the carrier frequency equipments are moved to other places where similar conditions prevail. In 1921 the Telegraph Administration began to purchase single-channel equipments from L M Ericsson, who had carried out considerable work of development in the domain. This Swedish firm has since 1936 been sole contractor for such plants and the number of single-channel circuits now amounts to about 115. Carrier frequency equipments for cable lines, both single and multichannel, are also supplied by L M Ericsson.

On the 4-wire lines there is generally superimposed still another circuit and later multi-channel systems have been introduced on unloaded cable circuits. When the Gothenburg—Malmö section was cablified in 1939, there were laid at the same time both a loaded cable and two unloaded cable pairs intended for carrier frequency. These latter two serve one for each speech direction and one line pair is now utilised for 12 channels, a number which is to be increased to 18. The two 19-pair cables Gothenburg—Helsingborg will then enable the connection of no fewer than 342 carrier frequency circuits. Between Helsingborg and Malmö the number of cable pairs is 14, which allows of 252 such circuits.

A beginning has also been made with the de-loading of circuits in cables previously laid. This occurred in the 1923 Stockholm—Gothenburg cable, where 10 quads for multichannel operation have been arranged, thereby gaining 160 4-wire circuits by giving up 30 2-wire circuits. On account of the higher attenuation in the unloaded cables there have been inserted between the former repeater stations new smaller stations with remote controlled intermediate repeaters.

Trunk Cable Network

The trunk cable network at the close of 1944 comprised a total length of cable of 5 728 km, stretching from Ystad in the south to Boden in the north. Owing to the greatly increased trunk traffic of recent years the trunk cables are heavily burdened, so that many new cable projects are now awaiting execution. The extent of the cablifying of trunk and rural circuits in Sweden will be seen from the figures below, relating to the close of 1944. At that time there were in service approximately 865 000 km of trunk circuits, of which app. 520 000 km physical circuits, app. 230 000 km phantom circuits

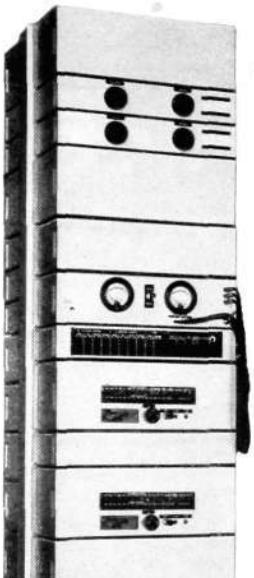


Fig. 24
Carrier frequency equipment
L M Ericsson's single-channel system

X 4428

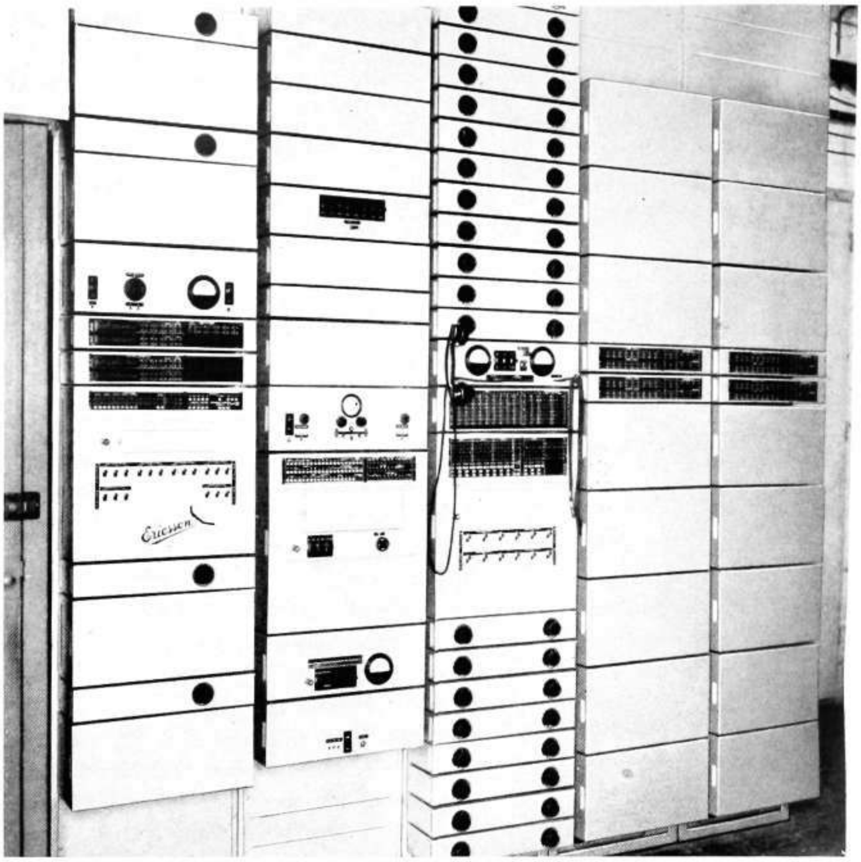


Fig. 25
Carrier frequency equipment
L M Ericsson's multi-channel system

X 6193

and app. 115 000 km carrier frequency circuits. Of the trunk circuits some 700 000 km or 81 % were laid in cables. At the same time the Telegraph Administration had about 445 000 km rural circuits. Of these some 194 000 km or 44 % were drawn in cables.

Sweden's Telephone Communications with other Countries

In respect of Sweden's telephone communications with foreign countries it may be mentioned that in the years 1891—92 there was constructed a line Örebro—Karlstad—Oslo. In 1893 there was arranged, by utilisation of the wires in a telegraph cable, the first telephone circuit between Malmö and Copenhagen.

Finland obtained via Torneå connection with Sweden in 1919 and the first telephone cable to Germany was laid in 1921. In the 1920s and 1930s the number of foreign circuits was greatly increased. Sweden then obtained direct lines to the most important telephone centres in Europe. By way of these it was possible to talk with all European and many extra-European countries. New ocean cables have been laid to Denmark, Finland and Germany and the underground cable network has been linked with Norway. If all cable reserves are included and the carrier frequency circuits provided for are also counted, then Sweden in 1939 had the provision for more than 300 telephone circuits with countries abroad.

The introduction of the telephone and its development in some countries have been dealt with at the beginning. It would take far too much space here to give a picture of subsequent progress of the telephone in foreign countries and moreover particulars are not available which would enable a survey to be made of the position in the last few years. Nevertheless a comparison of telephone intensity in some countries is shown by Fig. 26. Though the

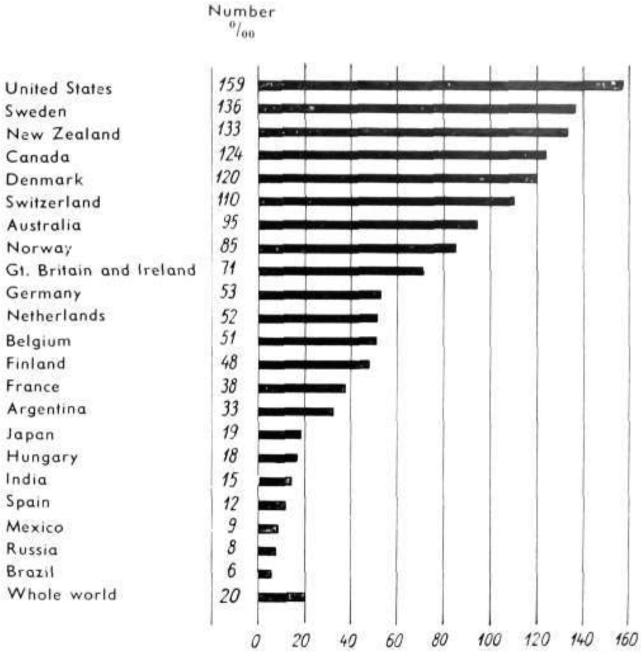


Fig. 26 X 6185
Graph showing number telephones per 1000 inhabitants in 1940

expansion of the telephone has been rapid in all countries, Sweden has well maintained her place. We too have followed the jump in development displayed by the years following the first world war.

The necessity for rapid communication has always stood out the strongest during times of unrest. In war intensive research and trials have been carried out without the slightest consideration of cost and when peace again prevailed the results have gradually been made public. Thus the beginning of the 1920s marked a new period of development in radio-technique and long distance telephony. Now that the last world war is over we may expect a fresh sharp advance in developments, but how they will turn out it is still too early to forecast. That prophecy may have its dangers may be seen from the extract from a Boston newspaper of 1867, with which we close this account.

»A certain Josua Coppersmith of New York has been taken into custody. He has attempted to fleece credulous people by exhibiting to them a device which, according to his claims, is capable of transmitting the human voice by means of connecting wires so that the speech can be heard at the other end of the line. The instrument he calls »telephone», which presumably is a plagiarism of telegraph. Well-informed folk know that it is impossible to transmit human speech through wire lines, and even were it at any time possible, such a device would not have the slightest practical value.»

Tele-signalling

TORE ERICSSON, ENGINEER, LM ERICSSONS FÖRSÄLJNINGS AKTIEBOLAG, STOCKHOLM

U.D.C 654.147(091)654.9(091)

Electrical tele-signalling may be said to date from *Oersted's* discovery in 1820 of the effect of an electric current on a magnet needle. Oersted himself, *Ampère*, *Schilling* and others immediately tried to utilize the discovery for the transmission of communications. The actual year when Schilling had his needle dial telegraph completed is not definitely known. *Wheatstone* and *Cooke* improved the instrument and applied for patent for their design in May 1837. In the same year *Steinheil* had completed his writing needle telegraph. Wheatstone continued to work on the problem and in 1840 he designed the first dial telegraph.

In the 1840s *W. von Siemens* and *Breguet* also designed dial telegraphs. The first of these was subjected in 1856 to a complete re-designing when Siemens invented the magneto generator.

As early as 1832 *Morse* had begun his attempts to design a telegraph instrument and in 1837 he was ready to make known his first instrument. It did not, however, find any practical employment before 1845.

The first fire telegraph was set up in Berlin by Siemens in 1851.
Experiments in operating clocks electrically had been begun in 1839 by Steinheil, when he tried to use pole-reversing impulses for the purpose. Nevertheless, the first to succed in finding a practical solution of the problem was *E. Stöhrer*.

Who actually invented the galvanic bell is not known with certainty, but the automatic interrupter in the bell was invented by Werner v. Siemens. The

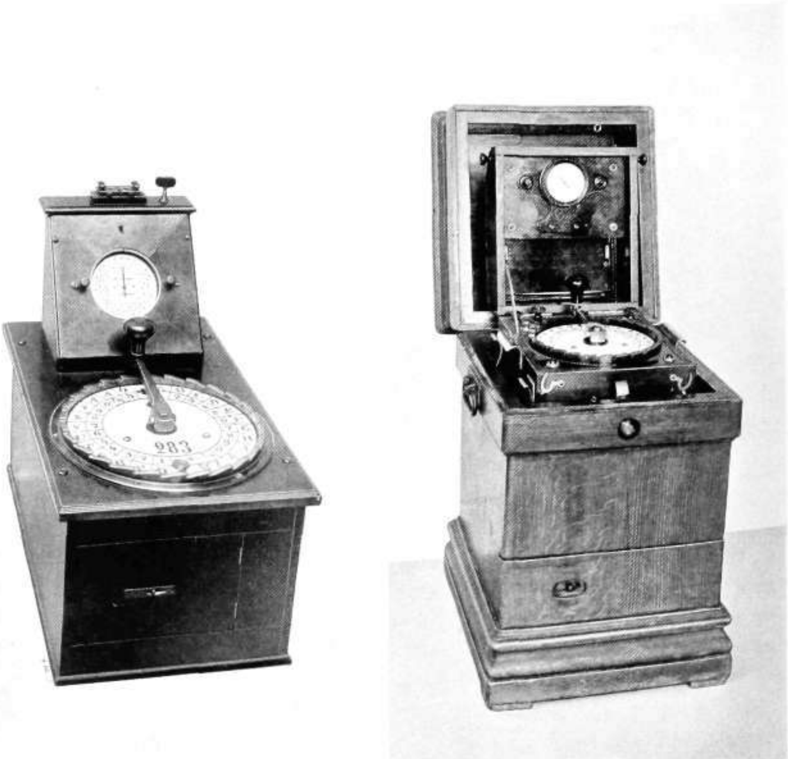


Fig. 1 X 6182
Dial telegraph instruments
left, stationary; right, portable for railways

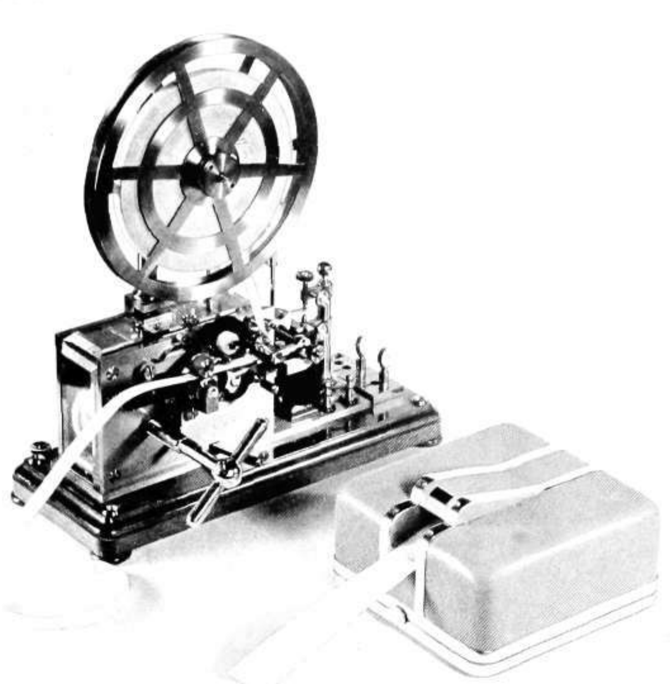


Fig. 2 X 6180
L M Ericsson's Morse telegraph instrument
left, 1885 model; right, latest construction

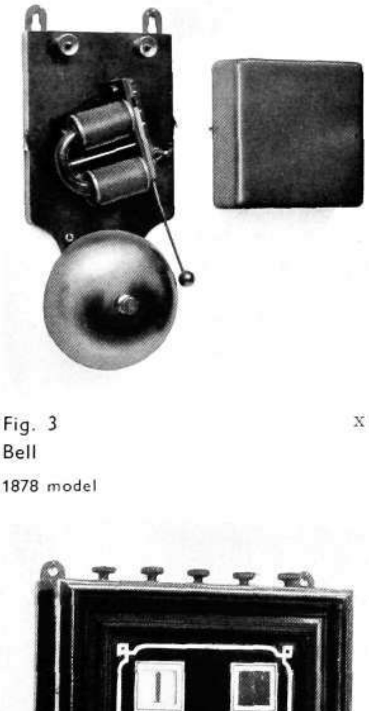


Fig. 3 X 4412
Bell
1878 model

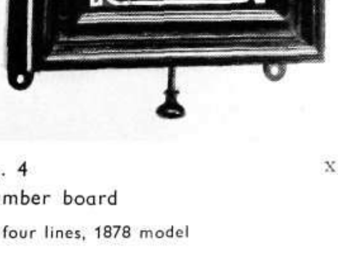


Fig. 4 X 4411
Number board
for four lines, 1878 model

first to use galvanic bells for practical purposes was *J. Mirand*, at Rouen in 1853.

When L M Ericsson started his undertaking in 1876, he was first engaged on the repair of electro-magnetic instruments.

The first client of the new undertaking was the Stockholm Fire Service, for whose account a dial telegraph was repaired.

Telegraph Instruments

Ericsson's first big delivery consisted of two dial telegraphs, in those days used by the railways for signalling between stations. These instruments, supplied to the State Railways, were of a design that had previously been manufactured both by Öller and Siemens.

As early as 1878, however, Ericsson on instructions from Director of Telegraphs *Stork* of the State Railways designed an entirely new receiving device for the dial telegraph and he also modified the transmitter device. The manufacture of dial telegraphs continued right to the middle of the 1880s, when the railways began more and more to change over to telegraph instruments on the Morse system. Ericsson's own design of Morse writer instruments would appear to have been complete in 1885. This design has since been manufactured almost without alteration right up to the 1940s.

In 1901 there was designed a modified instrument for employment in fire telegraph systems. As the railways in the last few decades have replaced telegraphy by telephony, the manufacture of telegraph instruments has been mainly concerned with instruments for fire telegraph systems.

It was not until 1943 that a new telegraph instrument, entirely differing from the earlier model, was designed. The length of life of the old instrument provides sufficient evidence of how well thought out and correct Ericsson's designs were. The telegraph sounder key that he designed is still being manufactured in conformity with the original model.

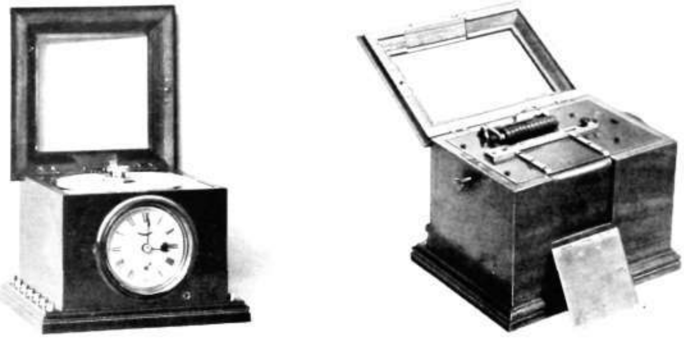


Fig. 5 X 6183

Night watchman control clocks

left, 1883 model in which the recording is done on a circular paper disc; earlier model, where the recording is on a paper strip

Besides ordinary telegraph instruments, Ericsson in March 1877 made a type telegraph instrument for the State Railways. From notes in the memorial this consisted of a type telegraph like previous ones, but with changes and necessary additions to produce figures and punctuation marks.

In addition it may be stated that the company during 1917 and 1918, at the request of the Board of Telegraphs and for its account, manufactured teleprinter instruments on the Creed System.

Signalling Systems

Bells and number boards for signalling systems were first supplied by Ericsson in 1878. Such instruments, however, are not to be found in any catalogue before about 1920, when Ericsson, Vienna, was engaged on the manufacture of annunciator boards and similar material. Work of development was also begun in the Vienna factory of the illuminated signal material, which was later more and more to replace the older system of bells and drop indicators. The continuation of the development and the manufacture of the illuminated signal material was transferred towards the close of the 1930s to the Stockholm factory, which is now manufacturing illuminated signal material for a variety of purposes.

Night Watchman Control

In December 1879 the first night watchman control instrument, which according to sketches consisted of a night watchman control clock for 8 posts, was supplied to the State Railways. That first instrument, which stamped the times on a paper strip driven by clockwork, was replaced in 1883 by an instrument in which the recordings were done on circular paper discs. In both cases, the plants consisted of stationary central instruments and stationary contact cabinets for the marking. The 1883 model of the night watchman control instrument continued to be made and sold right up to the 1930s, when the design was replaced by a more up-to-date instrument.

In recent years there has also been designed a portable night watchman clock. In that the marking is done on a paper strip driven by clockwork, the procedure being that keys placed at the various control spots are inserted in the clock and turned.

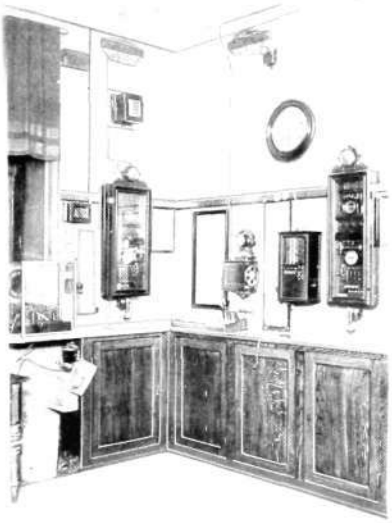


Fig. 6 X 4413

Interior view of the Västerås fire station with dial telegraph plant

The station was opened for operation in 1897 and the plant was still functioning in 1937

Fire Telegraph

Ericsson's collaboration with the fire brigades soon led him to begin the manufacture of fire telegraph systems. As early as 1878 there were delivered to the Sundsvall Fire Service various instruments, including fire alarm boxes.

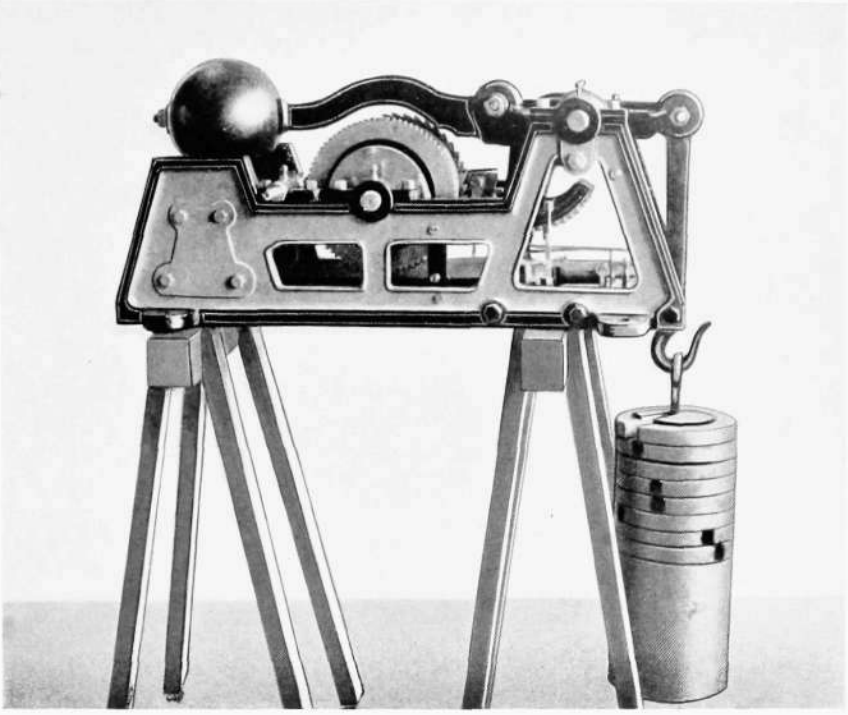


Fig. 7 X 6178
Bell tolling machine for fire alarm
exhibited at Paris 1881

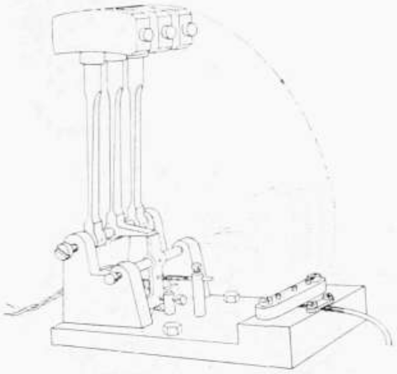


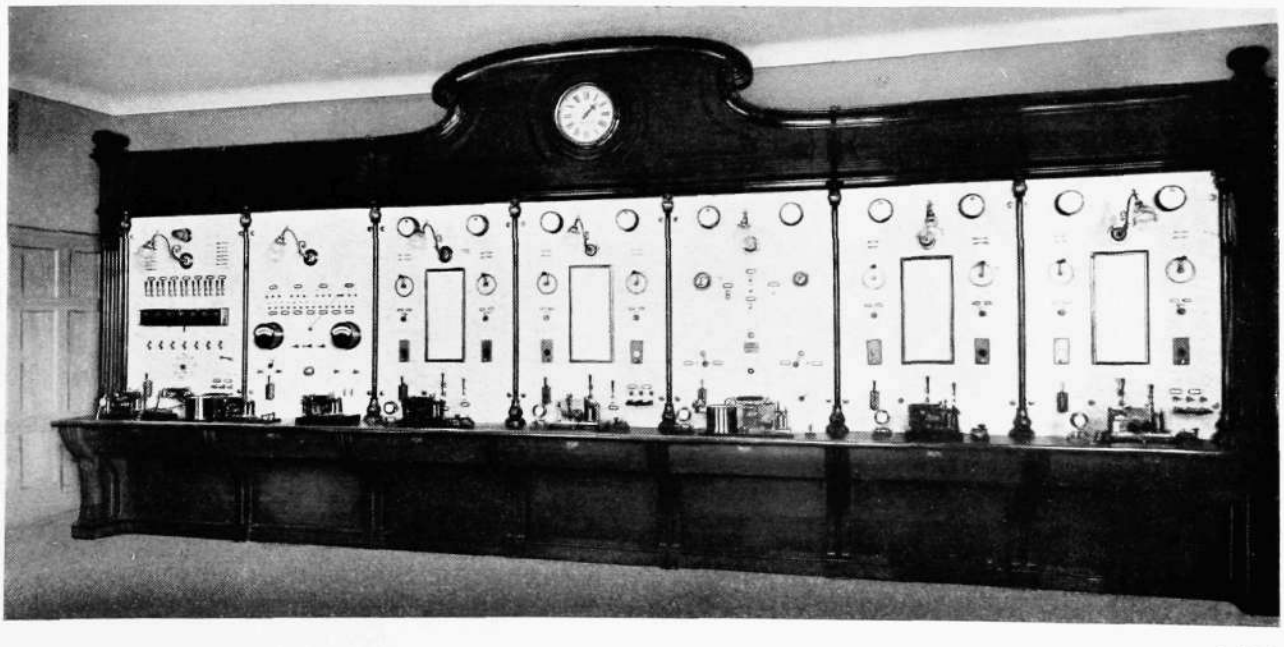
Fig. 8 X 4409
Hammer mechanism for the firing of cannon shots
Supplied to Visby in 1885

Two years afterwards he worked out models for a new automatic bell tolling apparatus for fire alarm and other instruments required for fire telegraph stations. Such a fire telegraph equipment was exhibited in Paris in 1881.

The bell tolling apparatus was designed for placing below the church bell, so that the hammers of the apparatus struck a blow on the bell each time the signal button was pressed. The necessary power was stored by winding up a heavy weight.

The same tolling apparatus as was exhibited in Paris was supplied to Visby in 1885. Visby, however, had previously also had fire announcing by means of cannon shots and the Visby people wished to retain this form of alarm. Ericsson therefore supplemented the apparatus by a unique design, namely an automatic hammer mechanism for firing the alarm cannon.

Fig. 9 X 7408
Interior of Johannes fire station, Stockholm, 1909



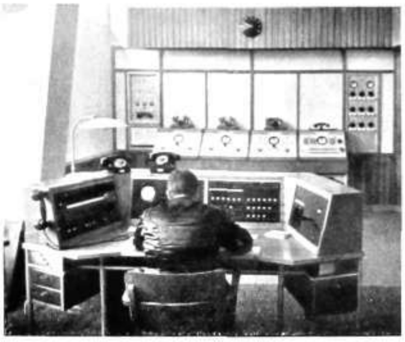


Fig. 10 X 4410

The telegraph room at Brännkyrka fire station

In the foreground, control board. In the background: the central fire telegraph apparatus with charging panel mounted flush in the wall at the right and the automatic fire alarm central instrument at the left

At the request of the then Director of the Stockholm telegraph station, Nyström, who was also inspector of fire services in the provinces, Ericsson worked out a fire telegraph system for the provincial towns. The first delivery of this system, known as the dial system, was made in 1885 to Karlskrona, and similar plants were shortly afterwards installed in most towns and large communities of Sweden.

The fire alarm boxes were so fitted that after the button had been pressed a fixed number of circuits was made, so that both the district and the number of the box could be read off at the fire station dial central apparatus.

The magneto generator system, intended for small towns and communities, was designed in 1917. The system now employed in large towns was designed in 1907 and in 1920 was subjected to thorough revision. Since then it has repeatedly been the subject of small modifications. In recent years fire telegraph plants have frequently been combined with police telephones, so that the lay-outs have undergone certain changes. At the same time the equipment has been given a more up-to-date appearance.

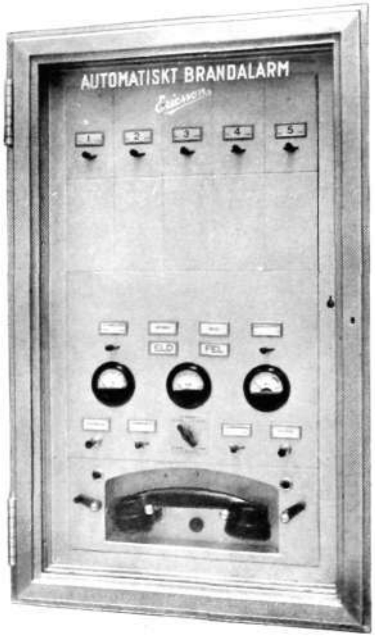


Fig. 11 X 4418

Central apparatus for automatic fire alarm plant

Automatic Fire Alarm

A firm concerned with fire telegraphy would naturally try to discover some method of automatic alarm in case of fire. L M Ericsson in 1890 designed contacts for this purpose, but for some reason this branch of activity was not further developed. It was not until 1926 that serious interest in automatic fire alarm began to be displayed. The system which then began to be manufactured was provided with two-wire circuit loops, in which soldering metal contacts sensitive to heat, known as thermo-contacts, were coupled in series. The loops were connected to a central apparatus comprising devices for electric supervision of the plant, receiving and indicating of alarm and fault signals etc. Alarm signal was registered when break occurred in the two wires of the loop. A single-wire break, shortcircuiting between the loop wires, leakage to earth or combination of these faults was signalled as fault.

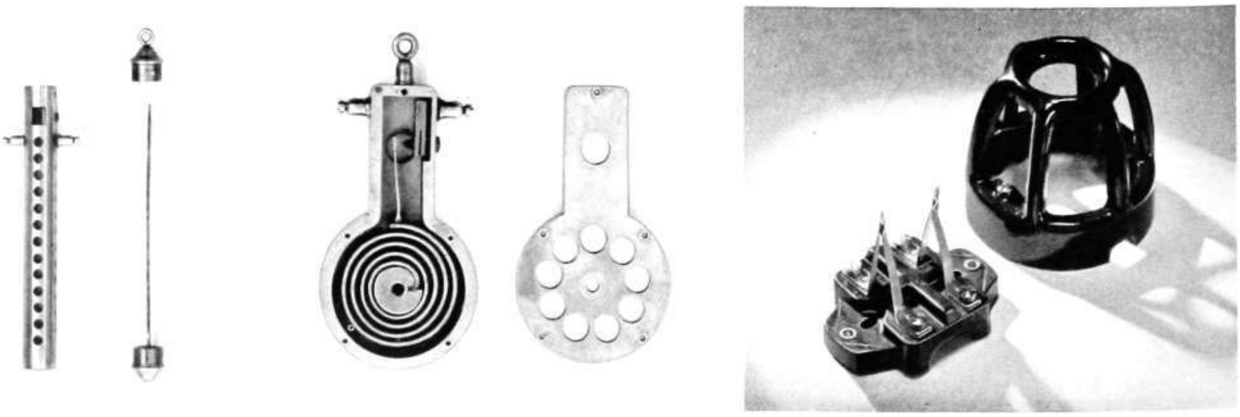
By means of this arrangement with double-wire current supervised loops there was attained an unusually high degree of security for the conveying of the alarm, while the risk of false alarm owing to line fault was reduced to a minimum. The efficacy of these plants was still further increased by the fire services agreeing to the connection of the central apparatus to the public fire telegraph network, so that alarm and signal could be transmitted direct to the fire brigade without any intermediary.

After a number of these plants had been in service and had also shown their worth for fires, the fire assurance companies showed their appreciation of

Fig. 12 X 7410

Thermo-contacts

left and in middle, fire signal contacts of 1890 for barns; right, thermo-contact of latest design



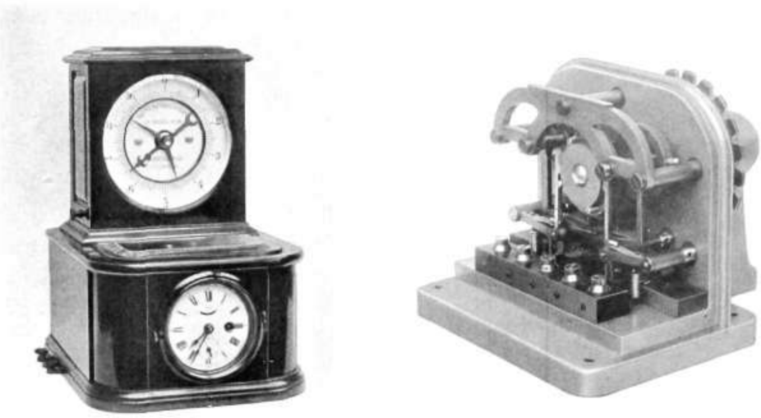


Fig. 13 X 6184
Water-level indicator
left, self-recording water-level indicator; right, impulse mechanism for water-level indicators of older construction

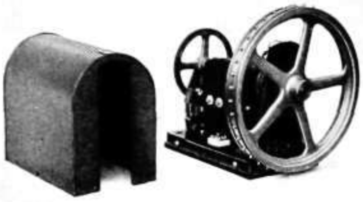


Fig. 14 X 4421
Impulse mechanism for water-level indicator of latest construction

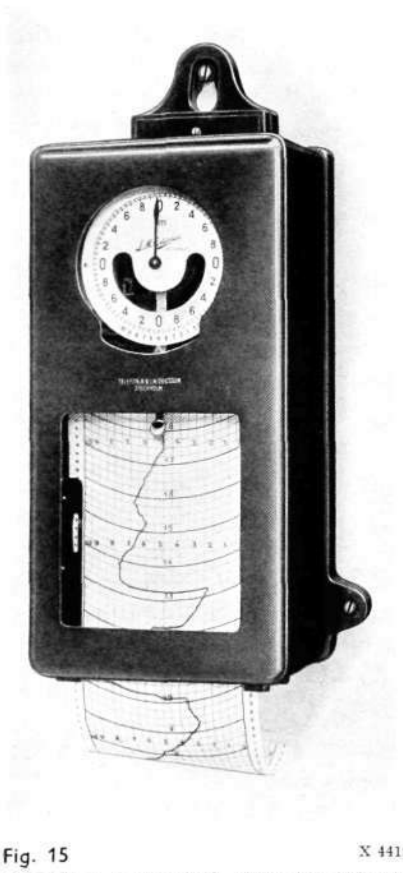


Fig. 15 X 4419
Recording water-level indicator of modern construction

them by granting rebates on fire insurance premiums for those risks where the L M Ericsson fire alarm was installed.

The basic principle of two-wire loops and automatic transmission of alarm and fault signals to the fire brigade is still applied, but the mechanical construction of the central apparatus was altered in 1936, so that while it had formerly been made for each individual case it could now be mass produced. The thermo-contacts are the same type as in 1926, but are about to be replaced by a new type with bi-metal springs soldered together having more rapid reaction than the former design.

Water-level Indicators

The first water-level instrument to be driven by galvanic cell was designed by Ericsson at the beginning of the 1880s and was succeeded in 1887 by a magneto generator driven water-level indicator which in principle was the same as that now used. In 1892 the apparatus was complemented by a recording device. L M Ericsson's water-level indicators have been installed in the course of the years at many places throughout the world.

Clock and Time Recording Plants

Among the recording apparatus referred to above were comprised mechanical clockworks manufactured in Ericsson's own factory.

Clockworks for ordinary clocks were not, however, manufactured before the 1920s. It is true that the tower clockwork mounted by the firm of Linderot in Ericsson's factory on Thulegatan was provided with a contact device which delivered 4 impulses a minute to a number of secondary clocks, made in the workshops, set up in the factory. But no business in clocks of this design was done.

In 1907 there was designed what is known as the Farad clock, driven from the strong current mains. This clock was sold to quite a large extent.

When the Stockholms Telephones Limited in 1918 sold its telephone plant to the Telegraph Administration and was reconstructed to form Industri AB H T Cedergren, this company began to look around for fresh manufactures for its workshops. In the autumn of 1918 work was begun on the design of a time recording apparatus and at the same time a start was made with secondary clock mechanism. The work of designing was about completed in 1921 when the Cedergren company was taken over by LM Ericsson.

The first installation of recording apparatus was made in 1921 at Norrahammars Bruk. In conjunction with the progressive moving of the manufacture of time recording apparatus from the Cedergren factory to the LM Ericsson establishment, certain re-designing of the recording apparatus was done to make the manufacture less that of a small workshop than it had originally been and also to make the apparatus more reliable. The first apparatus of this altered model were sent out from LM Ericsson's during 1924.

The apparatus in question for recording arrivals and departures have since undergone certain modifications, but in principle it is the same design that is still manufactured.

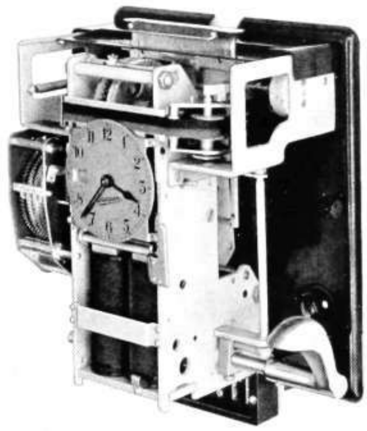


Fig. 16
Time recording apparatus
with cover removed

X 4422

With more or less the same components as used for the recording apparatus there were constructed from the beginning both a calculating recorder and a recorder for monthly records. The calculating recorder, like the recorder for weekly records, had automatic card setting, while the card slot on the monthly recorder was set by hand.

In 1936 there was completed a new design for the calculating recorder, made up of entirely new components. To begin with it was made as a monthly recorder but has since been complemented with recording mechanism for weekly records. The recorder types now made are fixed for mass production, but work on new designs is constantly going on to keep up the company's position in this domain.

The first secondary clock was delivered one year after the first recording apparatus left the factory, that is 1922, and mechanisms of this design were manufactured up to 1929. Since 1929 no change in the principle of the mechanism has been undertaken. Certain changes in design have been made to adapt the mechanisms to mass production. Hitherto during the time that LM Ericsson has been engaged with material for clock plants the master clocks have been purchased abroad, mostly from German makers.

In 1940 work on designing a master clock of Ericsson's own was started, on the basis of a design that had been made earlier in the French Ericsson factory. The result has been that the company has recently begun to supply master clocks from the first quantity of its own design.

Centralographs

In 1930 the company came into contact with a Hungarian engineer who had designed an apparatus for control of the running of machines, mainly with an eye to the textile industry. The inventor called his apparatus the centralograph and negotiations led to the purchase by LM Ericsson of the patent.

The first plants made in the company's factory were supplied in 1932 but even before that the inventor had himself sold a couple in Sweden.

The work of improving and developing the apparatus was immediately put in hand and by 1936 there had been produced the model of an apparatus that not only recorded machine time but also by means of a figure code in the

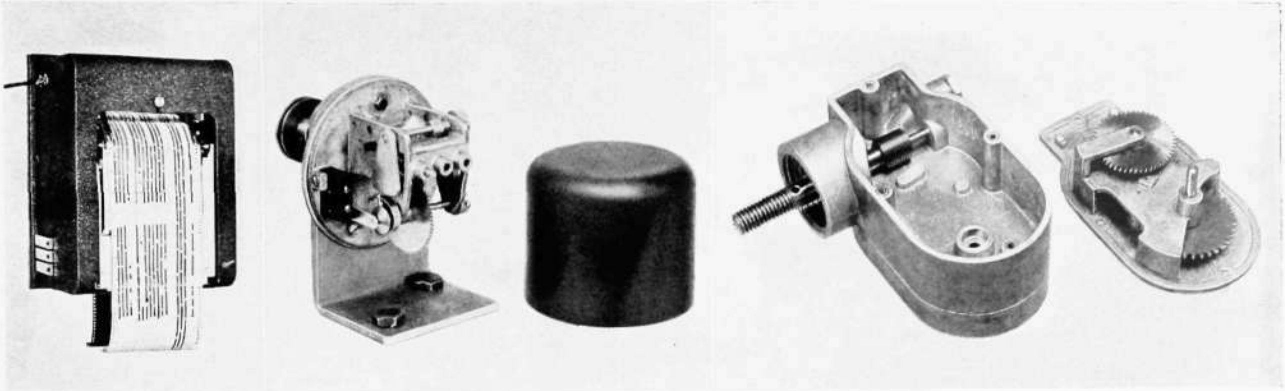


Fig. 17 X 7409
Centralograph, at left with impulse transmitter;
in middle, of older construction; at right, of later design

diagram indicated the causes of stoppages. A first trial lot was manufactured and these were submitted to prolonged tests. In 1943 the first of these apparatus were put on the market.

Miscellaneous Tele-signalling Plants

Besides the apparatus described above, which are made and supplied in large mass-produced quantities, the undertaking has from the beginning made single apparatus for tele-signalling plants of various kinds.

Thus LM Ericsson himself designed and manufactured signal plants for mines, the first of which was delivered in 1883, wind direction indicators combined with wind meters, both indicating and recording, water quantity and current direction indicators and burglary alarm plants.

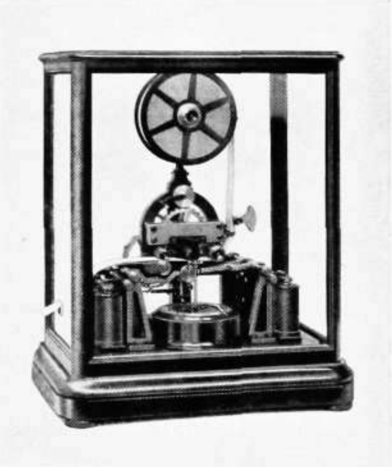
Later there were made mine igniters and fire control plants for the Navy, Parliament voting plants, stock exchange prices plants, timing plants for racing tracks, talking machines, location plants for hospitals etc.

In conjunction with the outbreak of the last world war the company made a big contribution by rapidly producing a reliable air raid alert system. This system was installed to a very great extent not only in Sweden but also in certain other countries.

Moreover in recent years what are known as central alarm plants for burglary alarm have been designed and such plants to begin with have been set up in Stockholm and Gothenburg.

Left, Fig. 18 X 4416
Dial instrument for mines
Delivered 1883 to C O Grafström, the Kärr mines

Right, Fig. 19 X 4415
Recording wind direction indicator and wind meter
1888 model



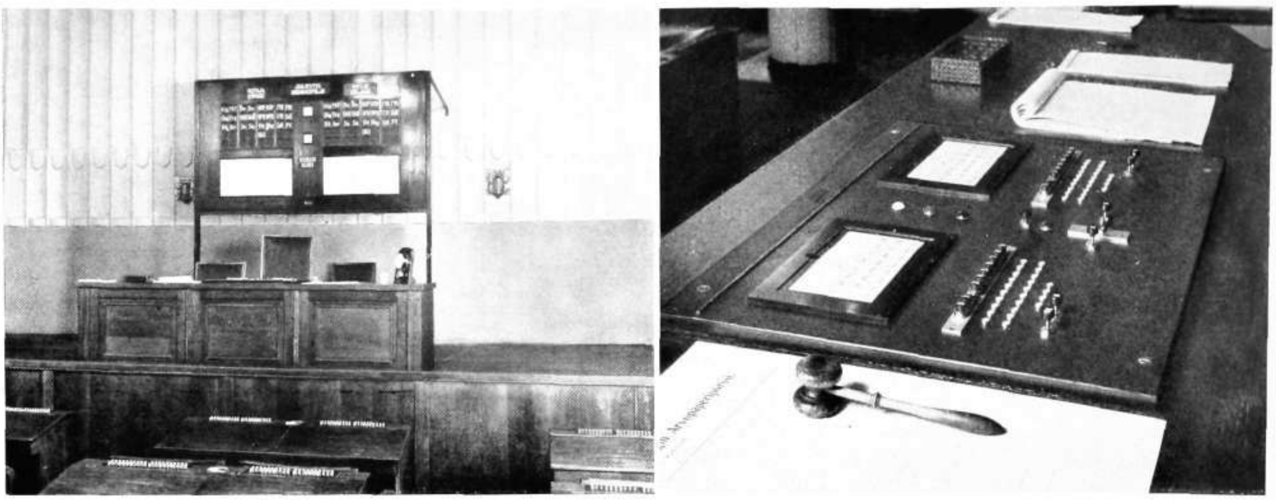


Fig. 20 X 7413
Price recording plant at Helsingfors stock exchange

left, prices board; right, stock exchange chief's equipment

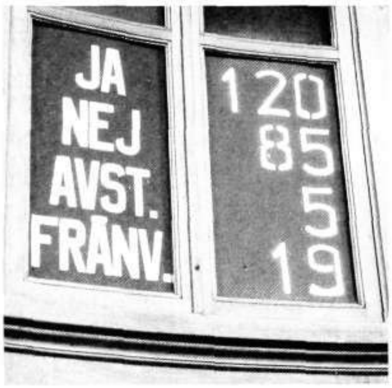


Fig. 21 X 4436
Results board for voting plant in the Riksdagshus (parliament building), Stockholm

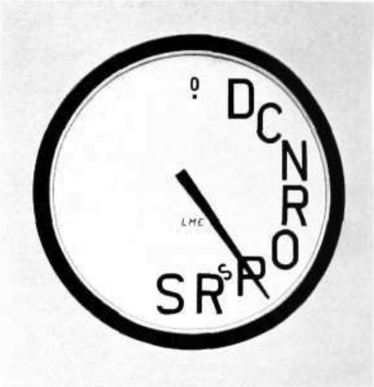


Fig. 22 X 4414
Dial locator

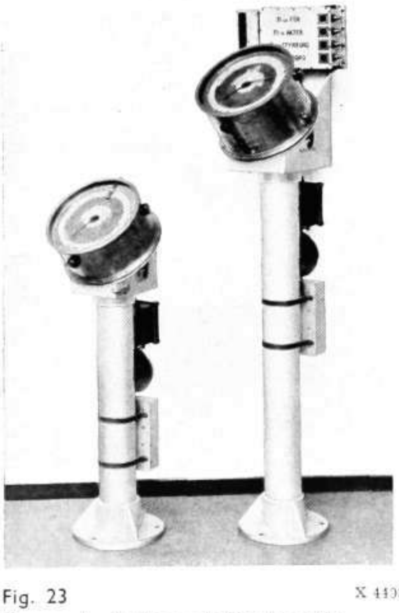
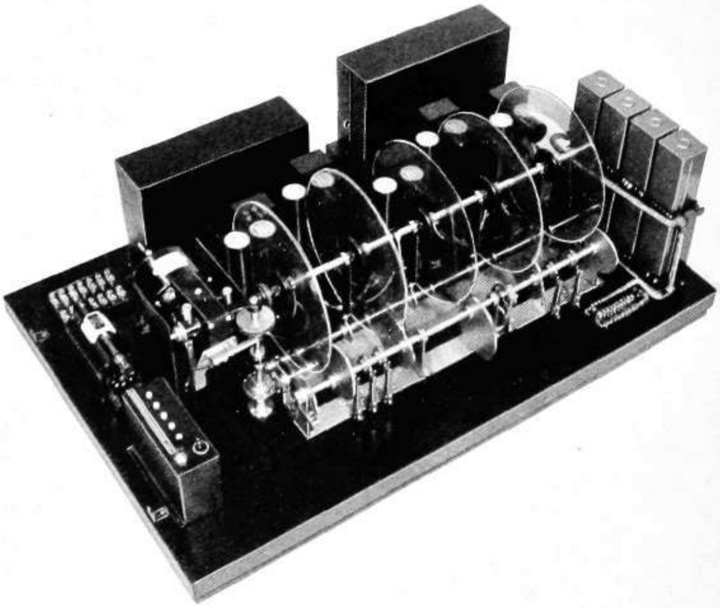


Fig. 23 X 4403
Fire control telegraph for warship

Fig. 24 (at right) X 6179
Time announcing machine



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Radio-Technics

T ÖVERGAARD, RADIO DEPARTMENT, SWEDISH TELEGRAPH ADMINISTRATION

U.D.C. 621.396(091)

An account of the development of radio-technics up to the present day, restricted to the space available in an article for a periodical, cannot be more than a collection of episodes. Numbers of researchers and engineers will of course be mentioned, but not the majority of them. Even the unknown radio engineer is behind this development and recognition of his important work therefore has its place here.

A century ago, as now, the technology of the future was entrenched in the men of science. The principle of energy had been presented four years previously but was still far from being recognised by the physicists of the day. Faraday's ingenious experimental investigations into the nature of electricity were available as raw material for the mathematical physicists of those days. The fundamental knowledge for radio technology was given by *Lord Kelvin* in his discovery of the electrical oscillation circuit. Kelvin's formula is still the one most employed in the technology of radio.

Maxwell's mathematical work on Faraday's investigations resulted in 1873 in his electro-magnetic light theory. This may well be described as the finest mathematical description of natural phenomena of the 19th century. Verification of this theory was provided by *Hertz* in 1887 in his famous experiment, which employed Lord Kelvin's oscillation circuit to produce waves of metre dimensions. Hertz demonstrated that electro-magnetic waves were a reality and of the same nature as light. It was natural to think of using these waves for remote communications and several researchers worked on these lines, such as *Branly*, known for his coherer, and the Russian *Popoff* who in 1895 succeeded in telegraphing over a distance of 4 kilometres.

It was *Marconi*, who began his experiments in 1896, that first succeeded in conveying radio telegraphy over a long distance. A reason essentially contributing to his success was his idea of using a vertical aerial that was made higher and higher and also of using an earth connection. The wave-lengths he worked on lay around 300 m. After a series of trials, in which the distance was progressively increased, he succeeded on 11th December 1901 in conveying signs by wireless between the giant station of Poldhu in Cornwall and St. John in Newfoundland. His system for the transmitter includes the aerial which itself constitutes a Kelvin's oscillation circuit, the oscillations being produced through a spark-gap in the aerial itself. The receiver device consisted likewise of an aerial and a coherer connected to it.

The stage from the transmission of simple signs to commercial traffic is however long and it took until 1905 before regular commercial traffic was exchanged across the Atlantic. Marconi had in the meantime found it an advantage to increase the wave-length for his experiments to 4 000 m. Definite traffic across the Atlantic was later exchanged over the station of Poldhu and Cape Cod, U. S. A. The speed amounted to app. 30 words a minute.

In Germany, under the patronage of Kaiser Wilhelm II, Professor *Braun* was working on a system much resembling Marconi's. As early as 1898 he introduced a special oscillation circuit, the spark circuit, to which the aerial was connected. The limit for Marconi's transmitting power was determined by the capacity of the aerial, the number of spark-overs in the aerial per second and the aerial voltage. The aerial thus had two functions, the production of the high frequency oscillations and radiating. These functions, however, in technical and economic respects are contrary to each other. The introduction of the Braun circuit, known as the intermediate circuit, meant that the two functions could be separated. The spark circuit had to generate the oscillations and the aerial had to radiate the energy.

There was also another system that was born in Germany, that of *Slaby-Arco* in 1897, behind which stood the German General Electric Co. This system was surprisingly similar to that of Marconi. After patent conflicts between the two German systems these were merged into one: »Telefunken». As might be expected the Telefunken system was first made available to the German navy.

At this time the big Atlantic passenger liners began to install radio stations as well, mostly of Marconi's make. Thanks to its fixed stations on the European and American coasts, the Marconi Company was at an early stage fairly predominant in respect of ships' radio traffic. In 1903 Germany sent out invitations to a radio conference in Berlin, at which the traffic between ships and land was to be discussed. The radio stations should be under obligation to exchange telegrams, irrespective of the system they represented. Officially it was humanitarian standpoints, especially the thought of disasters at sea, that animated the conference. In the background, however, lay an attempt to break the powerful position of the Marconi Company. Britain and Italy could not in the more important points accept the proposals put forward.

Theoretically the Telefunken system with the Braun intermediate circuit should be capable of delivering many times the power of Marconi's. It was found, however, that the aerial circuit, in addition to radiating energy, delivered an appreciable part of it back to the spark circuit, thus deteriorating the radiation and in addition obtaining two wave-lengths at one time in the aerial. This circumstance meant that the Marconi and the Telefunken systems were after all fairly equal. The weakness in the Telefunken system was overcome in 1906 by Professor *Wien* by his system of quenched sparks. Without going too closely into his idea, it should be stated that the problem consisted in quenching a spark gap and de-ionising it in an interval of some micro-seconds. His solution of the problem, known as the spark section, is both theoretically and practically one of the finest solutions produced in radio-telegraphy. The effect is ideal, the spark circuit delivers its energy to the aerial in perhaps 1/100 000 second, after which the spark circuit by means of the Wien spark section is disconnected, and the aerial radiates its energy in the form of slightly damped distinct waves. The number of sparks per second could in this way be in-

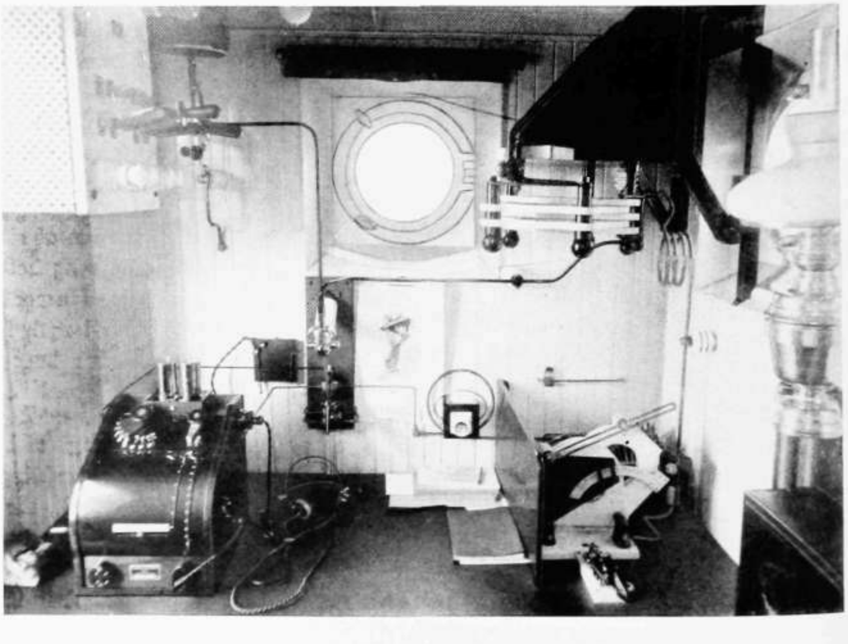

Fig. 1 X 6166
Typical German ship's station, system Telefunken, Rendahl, of 1920

creased from 30 to 1 000. The result was that in the receiver earpieces there was obtained a clear high tone, easily distinguishable from atmospheric disturbances. The system was worked out for Telefunken by its chief engineer, the Swede *Rendahl*, and was put on the market in 1908.

This system may be regarded as decidedly superior to Marconi's though the latter had likewise solved the problem by his rotary spark section. The Marconi system with rotary spark section has persisted for a long time in merchant ships. It is still possible to find ships equipped with this system. The Telefunken system with quenched sparks has still its importance as emergency transmitter in ships. Its reliability is practically 100 %, its efficiency from a technical standpoint is exemplary: from input 500 cycle power to high frequency energy in the aerial, 85 %. As example of large stations on the Telefunken principle we had in Sweden the Karlsborg radio in 1916, 80 kW, which was of great importance for Sweden's traffic with the Continent during the first world war and some years afterwards. The ranges attained with ship's stations in the time before the first world war were in the neighbourhood of 300 to 400 nautical miles. Some of the Swedish Transatlantic Co's ships had, however, communication with each other in the Indian Ocean at almost 2 000 nautical miles distance.

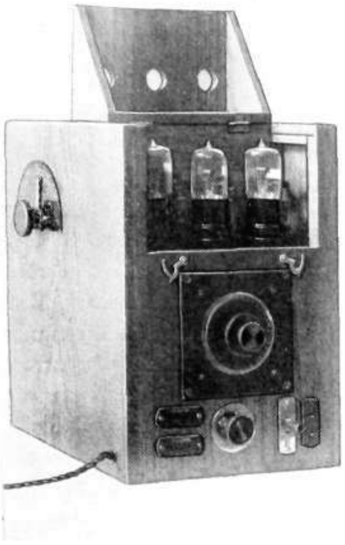

Fig. 2 X 4397

Ship's receiver with detector and 2-stage low frequency amplifier

Svenska Radioaktiebolaget's make 1921

The total number of coastal and ship's stations was

year	1913	1920	1929	1939
number	3 280	9 050	17 000	40 000

Illustrative of radio conditions of the time was the result of the international radio conference at Berlin in 1906, in which thirty states including the Scandinavian countries participated. The Conference led to the first International Radio Convention in a real sense and it fixed in the main rules for exchange of telegrams between coastal stations and ships. The Conference also decided on the establishment of an international bureau which should collect and publish information regarding radio telegraph stations. This bureau formed from the beginning a new branch of the already existing International Office in Berne.

The next international congress was held in London in 1912. Not least the Titanic disaster had prepared the ground for this conference at which the partially out-of-date convention of 1906 should be freshened up and extended to constitute greater uniformity. The Conference recommended the establishment of a network of coastal stations for the benefit of shipping and the regulation was introduced that ships provided with radio should also have an emergency radio station independent of the ship's source of power. In addition there were introduced international abbreviations (the Q code) and a certain system of attendance at the stations, especially for passenger ships etc.

In the time before the first world war, parallel with the developments of radio-technics described, there went on research work of considerable extent regarding radio transmission in general. The wave distribution theory established by Maxwell was further developed by many research scholars: *Zenneck*, *Sommerfeld* and others. The ionised air layer postulated by *Heaviside* at an early stage as laying at an altitude hundreds of kilometres above the earth, which even in Marconi's early experiments had had a certain influence on transmission, began to be investigated by physicists and this research has up to the present attained an enormous extent. Other domains of radiotechnics, such as the forming of the »corner-stones» of radio, resistances, coils and condensers, had undergone intensive development. Both shaping and insulation were of great importance. It was during this epoch that the Litz wires came out and also that knowledge of dielectric losses was deepened. The wave meter saw the light at the beginning of the century. The mathematical conditions for the treatment of damped oscillations were created in outstanding fashion by the Norwegian *Bjerknes*. About the same time, radio began to be used for other purposes, chiefly for direction finding, partly by the rotary frame indicated by Braun and partly by *Bellini* and *Tosi's* system with fixed frame.

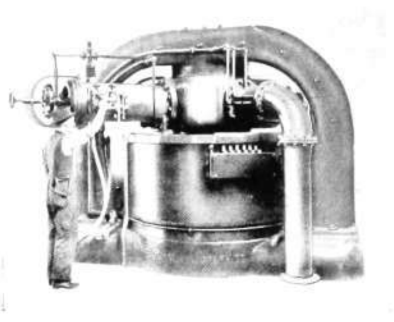

Fig. 3 X 4403
500 kW Poulsen generator

In respect of the equipment of the receiver side it is chiefly the detector that is of interest. As early as 1874 the above-named Professor Braun discovered the detector action in crystals. It was not until about 1906, however, that the crystal detector began to be generally used; Marconi's magnetic detector of 1902, *Schloemilch's* electrolytic detector 1903, *Fleming's* diode 1904 and *de Forest's* audion 1906 show the development in this connection.

The system that was to signify most for traffic between the Continents during the first world war and on to 1924, however, was produced in Denmark in 1906, where *Valdemar Poulsen* on the basis of *Duddel's* harmonic arc of 1899 created the first system with undamped oscillations in the aerial. *Lecher* 1888, *E Thomson* 1892 and Duddel 1899 had found that a Kelvin oscillation circuit coupled in series with a D.C. fed arc could in certain circumstances generate undamped oscillations. Prior to Poulsen these were of far too low a frequency for radio use. By enclosing the arc in hydrogen gas Poulsen succeeded in increasing the cycles to something like a million per second. He was also the first to telephone by wireless. Moreover his method of telephony found employment in the American Navy during the first world war.

The theoretical treatment of the oscillation problem with arcs and generally with circuits of falling characteristic has been developed chiefly through *Barkhausen* and *P O Pedersen*. The system is represented by *Lorenz A G* of Berlin, *C F Elwell* of London and the *Federal Telegraph Co.* of New York. It allowed of a tuning sharpness hitherto undreamed of and the transmitter has an efficiency of 50—60 %. The transmitters were made for powers of 30 W up to 3 000 kW for wave-lengths from 600 to 23 000 metres. In 1923 there were some 80 large stations on this system distributed over the whole world. The largest were Malabar 3 000 kW, Shanghai and Bordeaux 1 000 kW, Anapolis, USA, and Cavite on the Philippines and Pearl Harbour, Hawaii, for 500 kW. A high official of the General Post Office in London assured me in 1924 that better stations than Poulsen's did not exist. »They may be of any size and they are so simple that a nigger can operate them.»

At the same time as Poulsen, a rotating single-phase generator for 75 000 cycles per second and 0.5 kW was designed by *Fessenden* with the assistance of the Swede *E F V Alexanderson* in 1906. This type of machine was further

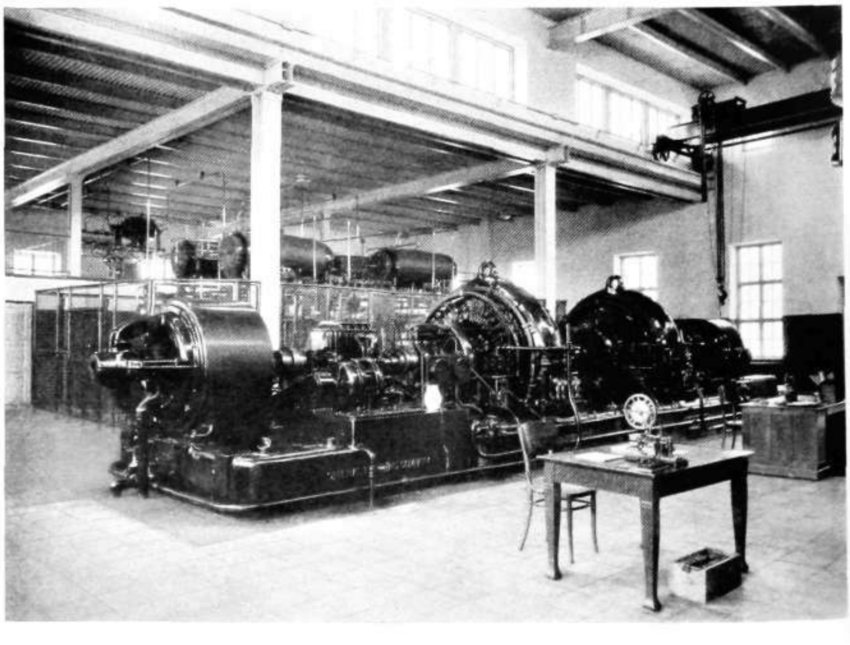

Fig. 4 X 6163
Alexanderson's 200 kW high frequency generator
Varberg radio station 1924

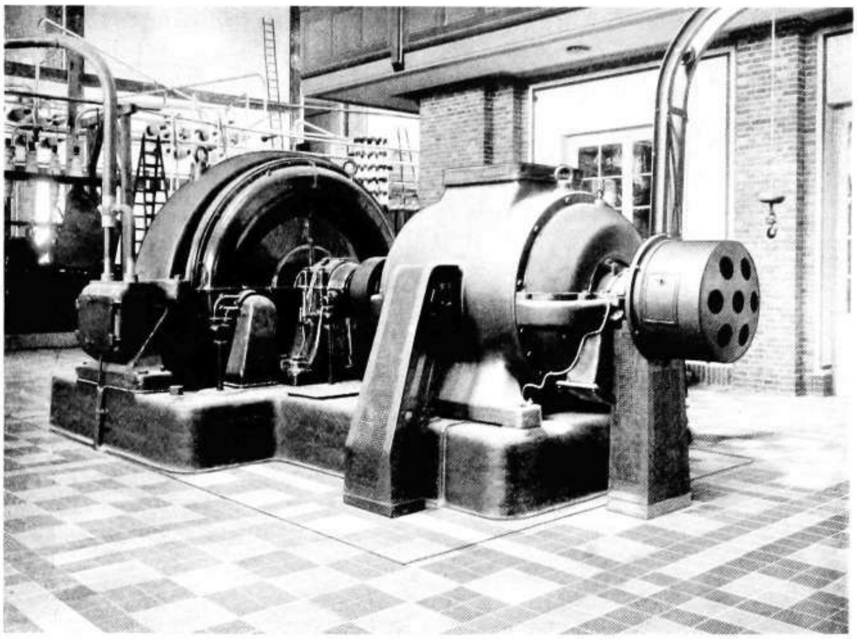

Fig. 5 X 6168
Telefunken 400 kW high frequency generator at Nauen radio station

developed by Alexanderson in the General Electric, Shenectady, and was employed by Radio Corporation of America in their trans-ocean traffic. The machine has been standardized for 200 kW and for cycles of about 15 000 to 22 000. To this system also belongs a special aerial, known as the Multiple Tuned Antenna, the radiating efficiency of which is appreciably superior to other long-wave aerials. The principle is a form of delivering energy to an oscillation circuit that had long been known. It is surprising that nobody had used the principle long before Alexanderson and it is evidence that the fresh glance of the discoverer is something quite different from mere theory.

Sweden's first radio connection with USA was established in 1924, the Alexanderson system being used.

Telefunken employed high frequency generators of moderate cycles, the cycles being raised in transformers. By deforming the transformer field by D.C. there were obtained overtones in the secondary circuit, these being later cultivated and further multiplied in fresh transformers. The typical Telefunken station on this system is Nauen 1919 with 400 kW machine output. There was also constructed in France a system with high frequency generators for equivalent traffic.

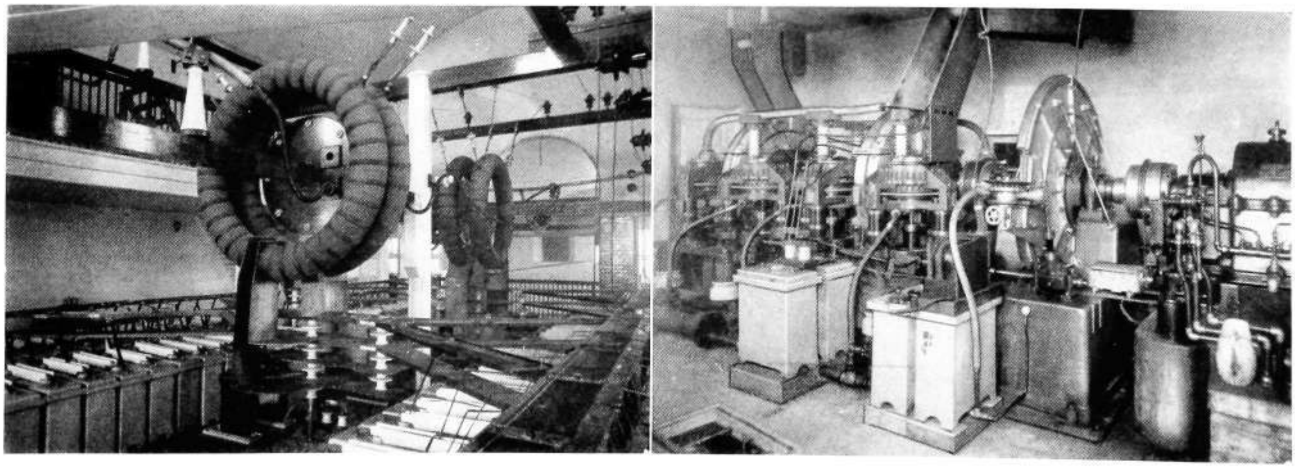

Fig. 6 X 7406
Inside view of radio station at Stavanger in 1917

Left, Marconi's long distance transmitter with three rotary spark gaps; right, inside view of the transmitter station

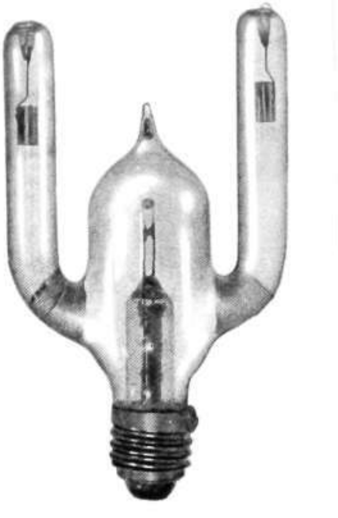

Fig. 7 X 4405
Rectifier valve with Wehnelt cathode, 1920

The Atom Traffic Makes Its Appearance

The discovery of electron emission from glowing bodies, a discovery of inestimable scope for civilisation, was made in 1883 by *Edison*. Manifolding of this »Edison power» was introduced by Wehnelt, who in 1904 demonstrated that oxides of barium, caesium and strontium produced considerably augmented emission. The phenomenon was utilized in *Fleming's* detector 1904 and in the electrode vacuum valve, the triode, designed simultaneously by de Forest and von Lieben in 1906. *Richardsen's* renowned equation for emission as function of the temperature and *Langmuir's* 3/2 exponent law for electron flow in vacuum constitute milestones in the development of radio valves before the recent world war. In the triode, radio practice had acquired an Aladdin's magic lamp. To begin with it was used as detector. In 1912—13 de Forest, *Armstrong* and Langmuir in America, Franklin in England, *Meissner* in Germany and *Strauss* in Austria, all independently of each other, discovered the return coupling, which at a stroke opened up the most fantastic prospects for the future for the technics of radio and high frequency. By means of the triode with return coupling there was obtained a convenient and inexpensive source of A.C., the cycles of which could be regulated to the region of 10 millions. It is difficult to decide in which domain this invention has had the greatest significance, for mathematics or for communication with or without wires. The triode also furnished the convenient facility of amplifying weak A.C. tensions with a precision hitherto unimagined.

On the Western Front in 1914—1918, where the armies dug into their trenches were seeking by means of listening apparatus to obtain knowledge of their adversaries' actions, the American Armstrong created the type of receiver which was given the name of super-heterodyne. Small valve transmitters began also to be made for military purposes during that war. As evidence of the conditions in Sweden, it may be mentioned that there was at the Technical University in 1918 an amplifier valve of Siemens make. It was kept in a velvet case, was stated to have cost 100 kronor and was used for laboratory work only by a few privileged persons.

The time up to 1924 was characterized by the building up of the theory of vacuum valves as amplifiers and generators, with the methods and terminology gradually becoming international. The receiver valves were usually triodes and double grid valves. Towards the close of that period the low temperature valves made their triumphal progress through the world. The transmitter valves were for small outputs up to 2½ kW. In special cases, with quartz glass it was possible to attain up to 5 kW. The high vacuum technique was of great significance in this connection. Pioneers in this domain were *Gade*, Langmuir and others.

As regards inventions, this period was characterized generally by an incredible number of receiver and transmitter couplings, among which may be noted *Hartley's* and *Colpitt's* 3-point couplings. The receivers consisted usually of detector and two-stage low frequency amplifier stages. The amplifier valves of those days had a disposition with high frequency amplification to get into oscillation. This difficult problem was solved by the American *Hazeltine* in 1923 with his neutralisation method, applied in the neutrodyne, which was regarded as the foremost type of receiver up to 1927—28 when an improved valve type, the screen grid valve, made neutralising superfluous. The development of the transmitter valve for large outputs, standardized to 10 and 20 kW, was worked out by the Western Electric Co. in 1922. Success was achieved in making a vacuum-tight join of copper and glass, so that the hot anode could form the outer wall of the valve and thus be cooled directly from outside.

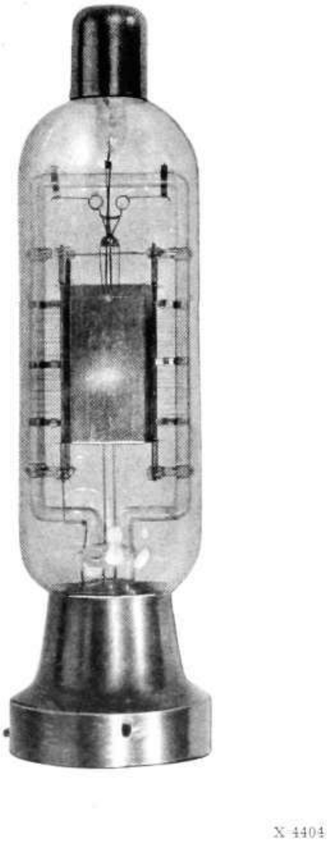

Fig. 8 X 4404
0.5 kW transmitter valve, Telefunken, 1920

Developments as regards long distance communication had since 1900 proceeded in the direction of longer wave lengths with increased distance. As years went by experience grew and resulted in the generally employed Austin's formula for radio transmission. Thus for traffic between the Continents waves of between 5 000 and 23 000 m were self evident. Developments in the domain

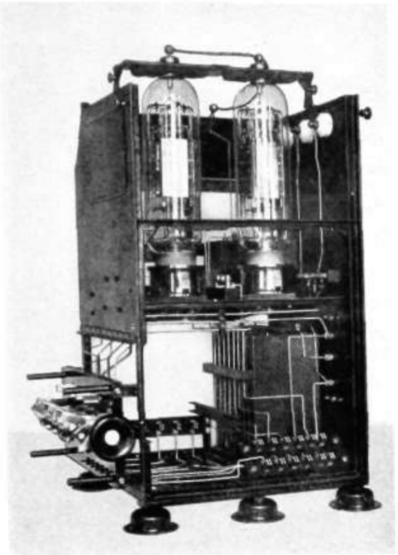

Fig. 9 X 4401
1 kW valve transmitter, type Telefunken, at Karlsborg Radio, Sweden, 1920

of the high frequency generator also contributed to views concerning the necessity of the long waves for long distance traffic becoming axiomatic. Marconi's main patent, however, applied to spark stations, which for the requisite outputs became cumbersome. It may be said that the Marconi system was technically outdistanced during the first world war by the Poulsen system.

Marconi, as the world's foremost »explorer of the ether» wondered whether wave lengths below 200 m might not be useable for long distances. At an early stage with ship's telegraphy 1901—1909 ships had been allotted a wave length area around 120 m for small output powers. It had then been found on several occasions at night that extraordinary ranges of 1000 up to 2000 nautical miles could be attained. Marconi therefore decided to make thorough investigation in this wave length area and in conjunction with Franklin he began in 1916 trials with wave-lengths from 2 to 15 metres. In these there was demonstrated in 1919 the quasi-optical character of the ultra-short waves and the sudden drop of the field intensity beyond the horizon. In 1921 there was arranged, as a trial, telephone traffic on 100 m wave-length between Britain and Holland, which trials turned out well. Quite unexpectedly, however, it was found that good reception was obtained in Oslo during the night and sometimes in the day.

The trials were continued in 1922—1923 from the historic station of Poldhu with parabolic reflector aerial, 97 m wave-length and 12 kW input power. Marconi's yacht Elettra was used as receiver station on a voyage from Southampton to St. Vincent in the West Indies. With these it was possible to demonstrate good commercial traffic conditions practically the whole twenty-four hours of the day and that with only 1 kW input power at Poldhu. The trials showed that waves below 100 m could give results over considerable distances.

Radio amateurs, who in Britain and America had been allotted wave-lengths below 200 m as these at that time were considered unsuitable for more important communications, succeeded in 1923 in bringing about two-way radio connection at night on 100 m wave-length between Britain and USA. More sporadic long distance communications could also be recorded by them. Marconi's continued trials at Poldhu resulted in 1924 in good telephone communication with Sidney, Australia, and a number of other places in the world also obtained satisfactory and continuous reception from Poldhu.

The General Post Office at this time had been planning a long-wave traffic system with Canada, Australia, India and South Africa. Marconi took then what was perhaps the boldest step of his life both financially and as radio technologist. He succeeded in inducing the General Post Office to interrupt the plans for the long-wave network and instead to lay down a brand new system for short-wave. The contract with the General Post Office comprised exceedingly heavy traffic demands. Thus, during 7 days uninterrupted test in both directions there should be maintained a traffic not falling below 100 words a minute, for 18 hours per day with Canada, 11 hours with Africa, 12 hours with India and 7 hours a day with Australia. Should this programme fail the General Post Iffice should not bear any other loss than that due to the time required for the establishment of the much more expensive long-wave network. The stated traffic capacity was appreciably greater than had previously been known in wireless and ocean cable traffic and the project was described generally as »a speculative jump into the unknown». It was mainly Marconi's own experience with directed beams on short wave and assuredly his extraordinary intuition that gave him courage to sign the contract.

The work of construction that followed meant in actual fact a multitude of problems in respect of transmitters, receivers and aerials, all of which had to be solved by trial and error. On 25th October 1926 the Canada communication for 16 m wave-length was opened and the other Imperial connections came into being the following year. At the delivery trials with the Australian connection the phenomenal speed of 350 words a minute was attained. The

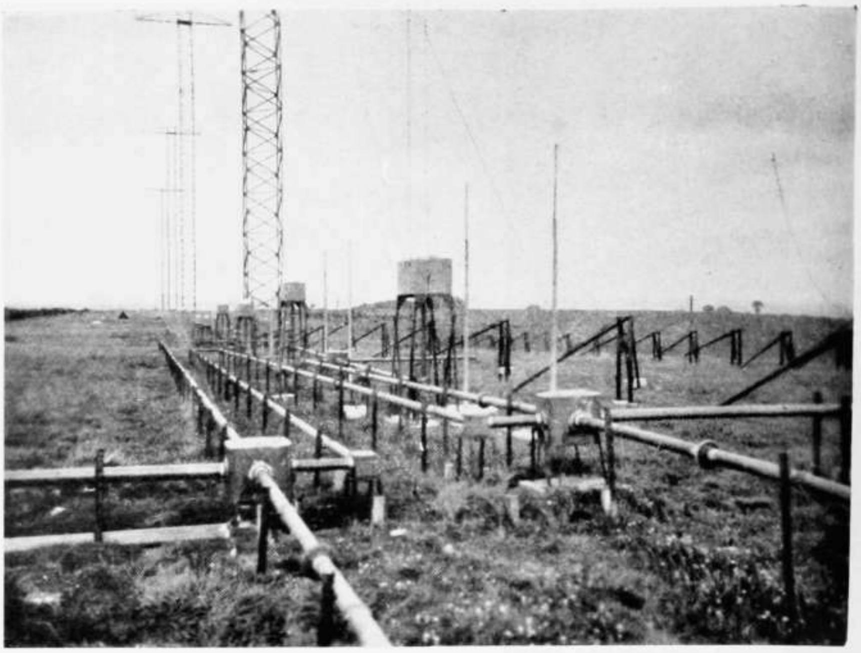

Fig. 10 X 6165
Typical Marconi-Franklin short-wave aerial plant
Dorchester 1929

success with this short-wave network was so complete that the competing cable companies lost a great deal of their traffic.

It was found, however, that the cables were of essential importance to the Empire and that it would be much more advantageous if radio and cable were complementary to each other instead of carrying on murderous competition. A gilt-edged company therefore was formed in 1928, The Imperial and International Communications Ltd., which took over the Eastern Telegraph Co., The Imperial Cables, the new Empire short-wave network and Marconi's long-wave network. The path shown by Marconi was quickly followed by the other big civilized powers, so that these at present have a number of short-wave radio connections for both telegraphy and telephony.

Technical progress since then has chiefly concerned direction aerials, among which in particular the Tannenbaum aerial introduced by Telefunken has found great favour. In this connection mention should also be made of the romban aerial invented by the American *Brown*.

The old long-wave stations with a traffic capacity of perhaps 1/5 and a power requirement 10 times these short-wave stations soon became out of date. Some of the old giants are still running today, however. A couple of days each year, when sunspots tear aside the connections for the short-waves, the ionosphere, they become once again »kings for a day» in the ether ocean.

It should also be recalled that before the short-wave asserted itself a great deal of work had been devoted to attempts to telephone on long-wave, one result being that Western Electric designed the single side-band system. The first commercial telephone traffic between the old and new world was exchanged by this system and was put into operation in April 1926. This system is still generally applied in short-wave telephony between the Continents.

Ultra Short-wave Technics

At an early stage of valve technics it was found that the triode's method of working and coupling as high frequency generator only permitted the generation of frequencies up to about 300 megacycles per second, i. e. 1 m wave length. For higher frequencies the conditions as stated were altered for the manner of working of the valve. New methods were required to attain still higher frequencies.

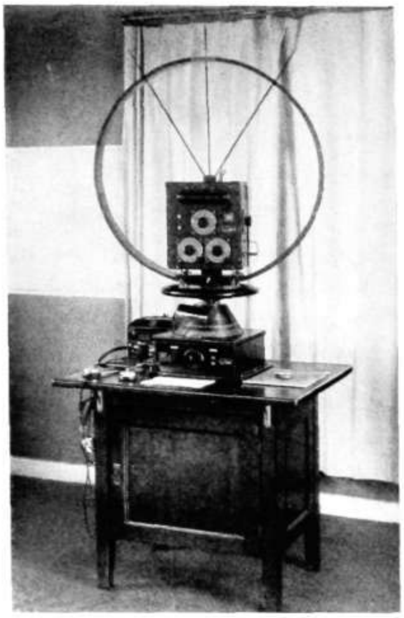

Fig. 11 X 4399
Direction finding receiver with Braun's frame

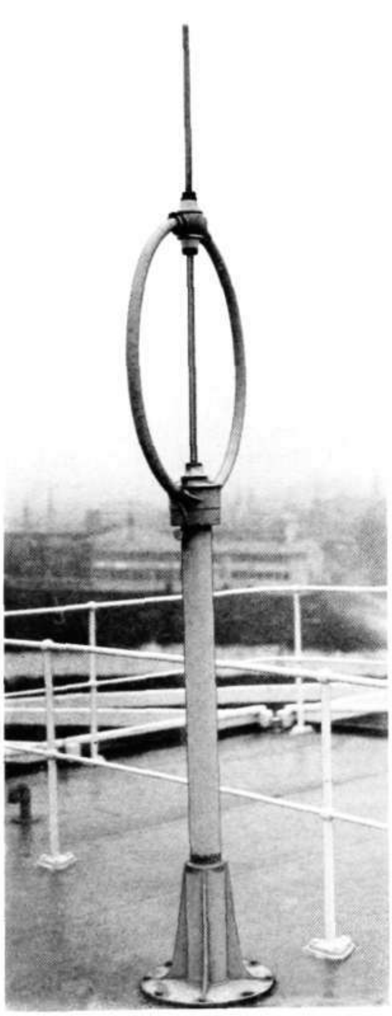

Fig. 12 X 4398
Rotary frame for direction finding receiver on board ship

Barkhausen-Kurz 1920 and *Gill-Morrel* used the triode in a new coupling, where the electrons were allowed to oscillate between the electrodes. For waves below 50 cm the efficiency drops very rapidly to below 5 %. By this system success has been achieved in getting out some few W.

Hull in 1918 invented another method, where the electron oscillations were controlled by magnet fields, known as magnetrone. Since 1933 this has been rapidly developed and before the war it gave better power and efficiency than the above method. A further development of Hull's system forms the foundation of the generators employed in echo-radio technics.

At the beginning of the late world war there was produced still another solution of the ultra short-wave generator problem, the clystrone, with what are called velocity controlled electrons, which seems to promise some 100 or more W power output with centimetre waves.
Echo-radio technics is now producing generators for centimetre waves which, momentarily for 1 microsecond, can develope 300 kW with 10 cm wave-length and 60 kW with 3 cm wave-length. Just before the war the limit of output was about 100 W, in other words a thousandfold output increase.

The naval and air war forced on the belligerents incredible efforts in the sphere of echo-radio technics. It has been claimed, though obviously with some exaggeration, that the echo-radio technics won the war and that the atomic bomb terminated it.

Just a few applications of this new technics will be referred to, such as the echo-radio telescope in which a picture of surroundings is obtained right through darkness, cloud and fog. An innovation of inestimable value for merchant shipping is the echo-radio localizer, which gives in a picture the direction and distance from objects round the whole scope of visibility within 80 nautical miles, with magnifying possibilities up to 2 naut. miles. The price including installation of such an instrument is estimated at present at 40 000 kronor.

Another masterpiece in echo-radio technics searches the whole heavens automatically and detects aircraft within 70 km distance. When the plane comes within 30 km distance, the instrument can be made to follow the target automatically and in conjunction with this automatically control the anti-aircraft defences. At each instant it gives particulars of the distance from the target with not more than 25 m error and 0.06° error in azimuth and elevation. The impulse power is 300 kW and its duration 0.8 microseconds. It was designed at the Massachusetts Institute of Technology Laboratory in April 1941, the final military tests were complete in February 1942 and the first firing tests took place at Anzio in February 1944. About a couple of thousand such instruments have been delivered, the price is approximately half a million kronor.

A terrifying weapon has been obtained in the echo-radio grenade, which explodes when it has come within effective distance of the target. The echo-instrument in this case must stand 20 000 times greater acceleration than for calling freely, the centrifugal forces on the projectile's rotation and — 60° C temperature. The problem was taken up in 1940 at the Carnegie Institution and the John Hopkins University. During the war 100 000 persons were engaged on the production of 20 million such projectiles and the cost was app. 1 milliard dollars.

The Importance of Radio for Navigation

As stated before, it was possible at an early stage (Braun, Bellini, Tosi) to take bearings on radio stations. For the benefit of navigation there were established in the early 1920s radio bearing stations along the coasts. A ship with radio could by means of this obtain its angle of direction from the bearing stations and thus determine its position. Since then the system has

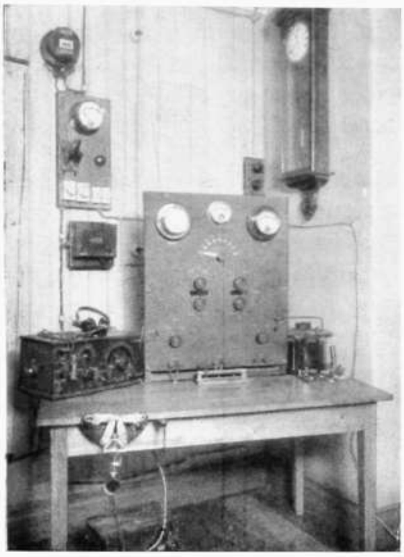

Fig. 13 X 4402

The Gothenburg coastal radio station 1919

Telephony transmitter

been supplemented in high degree by providing the ships with direction finding instruments on board. At present practically all ocean-going vessels are equipped with such instruments. The lighthouse services of many countries have extended their installations to include radio beacons in the service of navigation. The Baltic countries and Norway at a conference in Stockholm in 1932 agreed on a common radio beacon system of this kind.

For aviation the radio technics constituted a decided factor of safety. It is not more than 12—15 years since aircraft were keeping to the line of highways of or railways to be sure of not losing their course and preferably did not start if the cloud blanket was so low that such lines could not be used for guidance. Aviation therefore at an early stage made use of radio direction finding both in the aircraft and on the ground. For night flying, however, the older methods of taking bearings are unreliable, owing to the polarization distorting of the radio waves that takes place in the night. The solution of this problem was indicated by the Englishman *Adcock* in 1919. It was not until 1926 that his direction finding instrument was used and up to the war this method of obtaining bearings was predominant for aviation safety. The larger airfields in Sweden have for long been equipped with this type of bearing indicator.

In the 1930s the European countries came to agreement for a common triangle network of radio beacons for the benefit of aviation. The problem of blind landing has been solved in principle since the 1930s, the solution being since developed, chiefly by C Lorenz A G, Berlin. The system works on ultra-short waves and is such that from the far end of the runway there is transmitted a beam of such a kind that the crew of the plane landing hear different signals according to the side of the direction of landing they happen to be. Moreover the beam is so shaped that the pilot of the plane follows the beam in an instrument as a wide arc to the runway. The system further tested and revised in USA constitutes the standard for all large airports. By 1937 there were 35 such airport installations and 200 aircraft equipped with the instruments for blind landing.

Unlike the Europeans, the Americans have directed radio beacons between the airports, »radio lines» along which the air traffic runs. The intercontinental aviation realized during the war has made necessary a coordination of the European and American air radio systems, fixed at the world conferences in

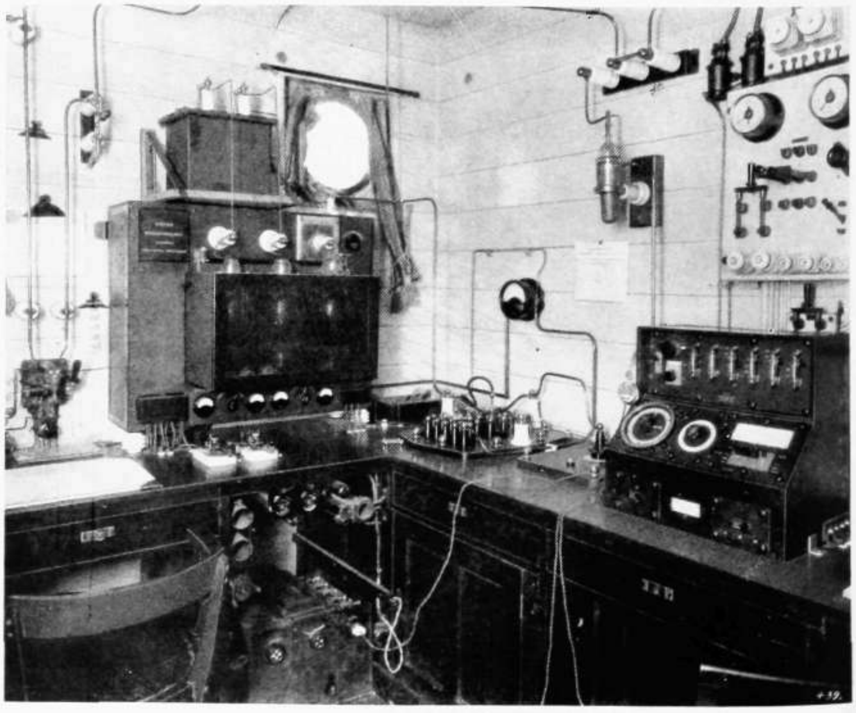

Fig. 14 X 6167

Radio station of s/s Drottningholm

left 1 kW valve transmitter made by Svenska Radio Aktiebolaget, rigt direction finding receiver, syrtem Bellini—Tosi, of Marconi's make.

Chicago 1944 and Montreal 1945. Through this, new aids to navigation have been added, that have sprung up during the war, such as the echo-radio collision averter and the Loran system for long distance navigation. Synchronized impulses are emitted from transmitter stations on the ground, these being received in the aircraft. The impulses are given varying time characters according to where they are read, which Loran charts established in advance permit. From the character of the impulses read the pilot can read the plane's position direct on the Loran chart. The system permits a trained navigator even to take signals reflected against the ionosphere, which enables the system to be used up to 1 500 nautical miles. Further serviceable systems have come out during the war and may be expected to have importance for the navigation of both aircraft and ships. One of these was used for the invasion of France. By it ships could determine their position to within 7 m at the entrance to the Scheldt guided by signals from radio stations in England.

Broadcasting

After the first trials with broadcasting had been made in the United States towards the end of 1920, this new means of communication made extremely rapid progress in that country and quickly spread over the world. In France regular broadcast emissions were begun in the middle of 1921 from a military station in the Eiffel Tower. At the beginning of 1922 the Marconi Company in England obtained permission from the authorities to broadcast music programmes by radio once a week and at the close of that year the British Broadcasting Company was formed.

As regards Sweden, the government on June 29 1923 approved the broad lines of broadcasting, according to which it was the State that would establish transmitting stations. The question of programmes, however, was to be handed over to private enterprise. The first practical trials with radio broadcasting in Sweden began at the training establishment of the Telegraph Administration in Stockholm, where from September 1922 to the close of that year a half hour's programme was transmitted each evening. At the beginning of 1923 Svenska Radioaktiebolaget started trial broadcasts three times a week from its factory on Kungsholmen in Stockholm. From the costal radio station of Nya Varvet at Gothenburg there were broadcast regular weather reports during the summer of 1923. From the Boden costal radio station also broadcasts were undertaken about that time.

The technical basis for Swedish broadcasting was the trial station at Stockholm of the Telegraph Administration, the first transmitter specially built for broadcasting, with an output of 0.5 kW, in the autumn of 1923. The

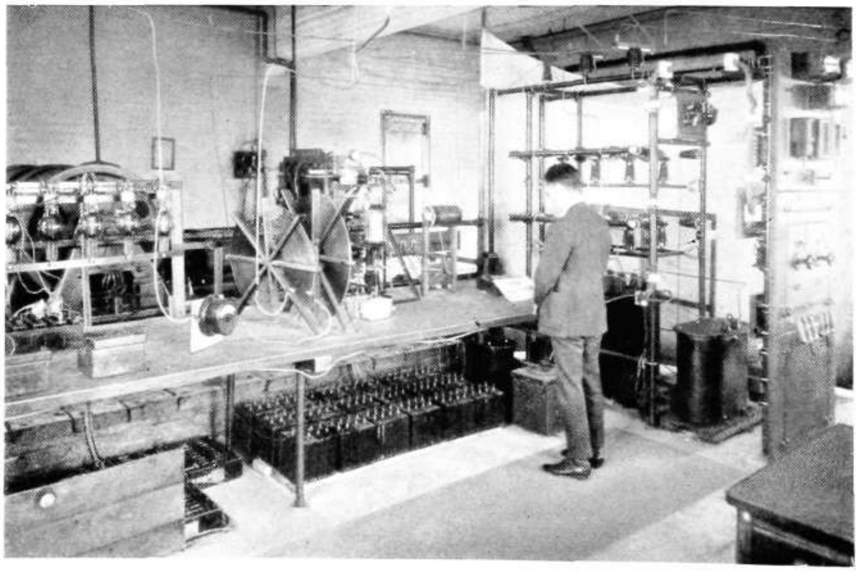

Fig. 15 X 6169
Inside view of broadcasting station WGY (USA) 1922

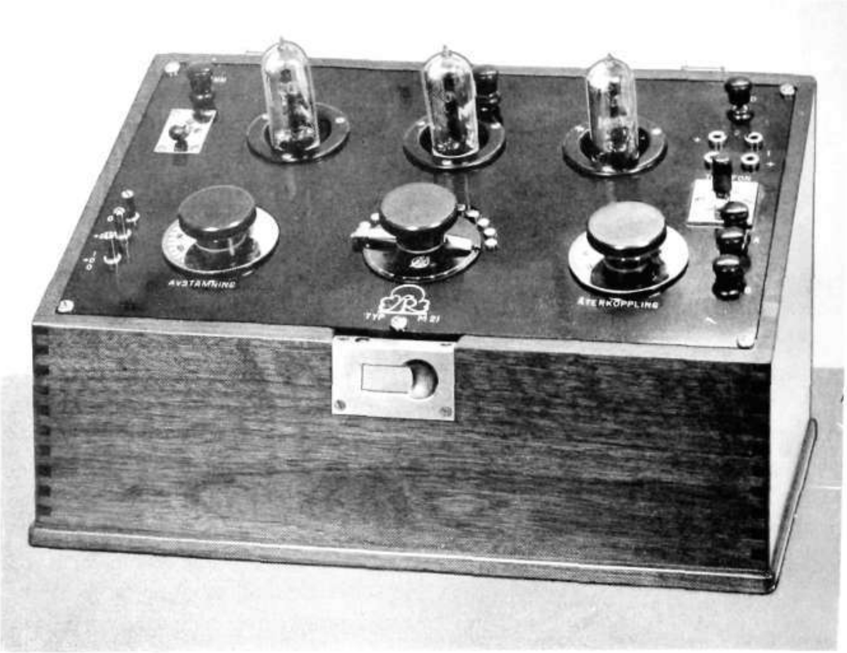

Fig. 16 X 6164
Radio receiver of Svenska Radio Aktiebolaget's make 1921
The receiver is equipped with 3 valves, one as detector and two as low frequency amplifiers.

station which was made by Svenska Radio Aktiebolaget was housed in the training establishment of the Telegraph Administration at Malmskillnadsgatan, where a lecture hall was converted into a studio. With this installation trial broadcasts were carried out, as also a number of tests and experiments of a radio technical and acoustic nature, providing useful experience which was to be of great value in the technical lay-out of later plants.

During the whole of 1924 there were regular broadcast emissions from the laboratory of Engineer *K G Eliasson,* on his own initiative.

New licence regulations came into force on 1st January 1925. The charge was then 12 kronor per year. From the beginning of 1926 the licence fee has been 10 kronor per year. On 27th September 1924 the Board of Telegraphs was authorised to erect 5 broadcasting stations, at Stockholm, Gothenburg, Malmö, Sundsvall and Boden. At the opening of 1926, when AB Radiotjänst (the Swedish Broadcasting Corporation) started operations, the Board of Telegraphs could place the new stations in Gothenburg and Malmö together with the experimental station at Stockholm at the corporation's disposal for the broadcasting of the opening programme. During 1925 there were set up on private initiative broadcasting stations in 15 towns. A further 7 private stations were added during 1926. The demand of rural districts for a station with greater power was met in 1927 by the 30 kW station at Motala. In 1928 the power of the Gothenburg station was increased to 10 kW, as was the case with the stations of Sundsvall 1929 and Hörby in Scania. Finally the Brunkeberg transmitter in Stockholm was replaced by a broadcasting station of 55 kW at Spånga outside the city. Stations synchronously operated were established in 1932 at Karlstad, Norrköping and Trollhättan. The result was so satisfactory that another group of synchronous stations was formed in 1935 at Umeå, Hudiksvall and Örnsköldsvik.

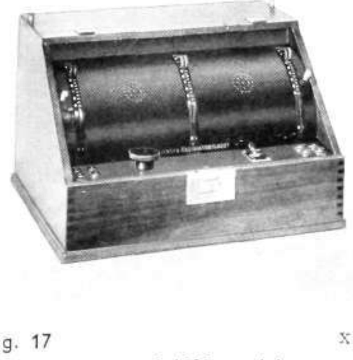

Fig. 17 X 4400
Radio receiver of 1925 model
Radiola M 25 IV

The keen international competition for wave-lengths had in the course of years resulted in a race between the countries, during which the transmitting powers of stations were progressively augmented. If Sweden was to have any chance of retaining the wave-length that Swedish delegates had secured at the international radio congresses there was nothing else to be done than to occupy these wave-lengths with transmitters of the greatest permitted power. In consequence the Motala station was extended for 150 kW in 1935 and the Hörby station to 100 kW in 1937. In 1938 the old station at Boden

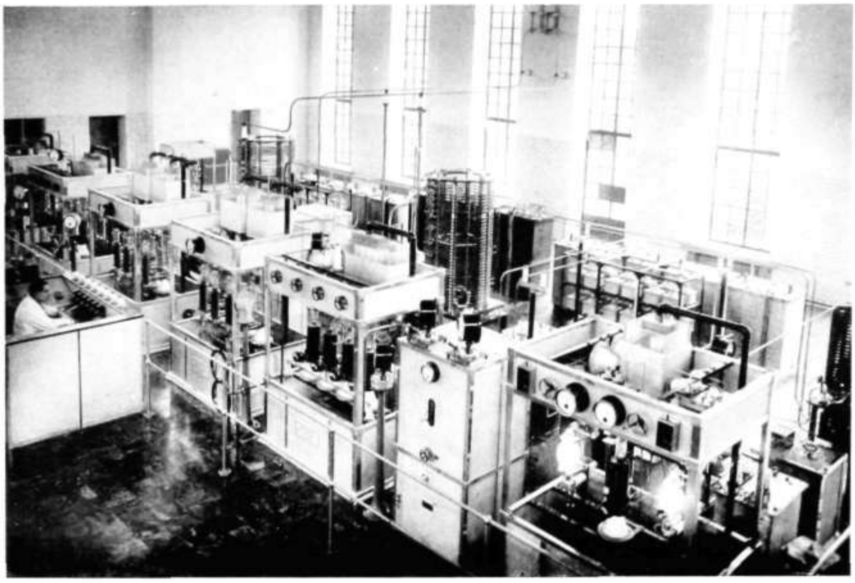

Fig. 18 X 6162
Inside view of Motala broadcasting station 1927
30 kW transmitter

was replaced by a new broadcasting station at Luleå for 30 kW. The latest big plant in the broadcasting network was added in 1939 with the 100 kW station outside Falun.

Technical developments in broadcasting stations are in many respects connected with progress in the methods of modulating. Special reference should be made to *Heising's* anode modulating of 1920 and the frequency modulating realized in practice by *Armstrong* in the 1930s. The frequency modulating, the great advantages of which as regards disturbances were first only felt in the ultra short-wave range, has been applied at a large number of broadcasting stations in the United States as a complement to other broadcasting.

The crowding of the ether in the broadcasting bands, which compelled the states of Europe to arrange a receiver station at Brussels for control of broadcasting stations' wave-lengths, meant a particularly sharp frequency constancy in the transmitters concerned. Foremost aid for this is to be found in oscillating crystal. The oscillation properties of crystals, discovered in the 19th century by the brothers *Curie*, were theoretically expounded by *Cady* in 1921. In the domain of broadcasting receivers the construction of the modern mixing valve in 1932 meant that the super-heterodyne receiver surpassed in quality the earlier neutrodyne and became practically predominant among the types of receivers.

Television

Photo-electric power was discovered accidentially by *Hertz* during his experiments to check the theory of electro-magnetic light. The discovery was worked on by *Hallwachs, Lanard, Elster, Geitel* and others but no satisfactory explanation was obtained until *Einstein* 1905 with the aid of *Planck's* quantitative theory established his renowned equation for photo-electrical emission, for which he was awarded the 1921 Nobel price. The technical result, the photo-cell, has now attained a high degree of perfection and in *Zworykin's* iconoscope of 1933 has provided us with the most ingenious means of transforming light impressions into electric current. The necessary reverse procedure of converting the electric current to light had been done earlier by several methods, *e. g.,* in the Kerr cell. It is now chiefly done by cathode beam valves, which were highly perfected during the war. Television has gone through a number of stages of development but it was not until the above mentioned instruments that it could be realized in useful form.

Owing to the enormous number of light impressions, several millions a second, that must be transmitted by radio for television, the wave-length in television, must lie in the ultra-short wave, under 10 metres wave-length. As the ranges of these waves are limited by the horizon the sphere of employment of television is directed to densely built up centres. The largest television system at present is that of the National Broadcasting Company at New York, which from its station at the Empire State building transmits programmes over New York and, via ultra short-wave connections, to Schenectady and Philadelphia, where the relaying is done over amplifiers. The Americans are extremely optimistic about the future of television and it is reckoned that in the regions named, with a population of 30 millions, hundreds of thousands of television receivers can be disposed of, which with light and 10 × 8 inch size of picture would cost about 200 dollars at pre-war prices. During the war the Radio Corporation of America has developed a television cathode beam valve of small diameter and such intensive picture point that the picture can be amplified direct and give good light intensity on a cinema screen.

The electron optic developed in conjunction with television, which at present plays an important part in the computation of new valves, has also led to the construction of electron microscopes with a dissolving property some 100 000 times greater than in light microscopes. Siemens of Berlin have been the pioneers in this respect.

It has only been possible to give a summary account of developments in the field of radio technics that entirely falls within the very short period, in this connection of half a century. Nevertheless we are but little acquainted with what has been done in this domain and its various branches during the last six years. We do know that it has exercised a great influence on war operations and one may venture to hope that it may be applied also in peace conditions to the benefit of humanity. We know also that the big industrial countries have gained a considerable advance over our country of Sweden. We can only try to make up this lead by energetic work and purposeful research and once more take up our position in the front rank.

U.D.C. 92 Ericsson L M

JOHANSSON, H: *Lars Magnus Ericsson — a Brief Biographical Sketch.* Ericsson Review *23* (1946) No. 2 pp 105—120.

The article opens with a copy of LM Ericsson's report on his journey of study abroad. His early years are described. LM Ericsson becomes a pupil of A H Öller, and opens his own machine shop on 1st April 1876. Graham Bell's invention, the telephone, leads LM Ericsson to arrive by experiment at improved types of telephones. LM Ericsson beats the Bell Company in competition for the construction of a telephone network at Gefle. Stockholms Allmänna Telefonaktiebolag takes up the competition with the Stockholm Bell Company. Brief description of LM Ericsson's character.

U.D.C. 621.394(091)621.395(091)654.1(091)

HEDEN, N: *Telegraphy and Telephony.* Ericsson Rev. *23* (1946) No. 2 pp. 122—149.

Oersted's, Argo's, Sturgeon's and Faraday's discoveries in electrotechnics were to show the way for telegraph and telephone technics. The first telegraph systems. The first spreading of the telegraph network and the introduction of telegraphy into Sweden. Transition to newer telegraph systems. Sweden's telegraph connections with foreign countries. The telephone and its development in different countries. Lines.

U.D.C. 654.147(091)654.9(091)

ERICSSON, T. *Tele-signalling.* Ericsson Rev. *23* (1946) No. 2 pp. 150—160.

Electrical tele-signalling technics may be said to have arisen in and with Oersted's discovery of the action of electric currents on a magnet needle. The work of the undertaking started in 1876 by LM Ericsson consisted to begin with in repairing electro-mechanical instruments.

In the article there are described the tele-signalling systems designed and manufactured by LM Ericsson up to the present day, such as telegraph instruments, signalling systems, night watchmen control, automatic fire alarm, clock and time record plants, centralographs etc.

U.D.C. 621.396(091)

ÖVERGAARD, T: *Raio-technics.* Ericsson Rev. *23* (1946) No. 2 pp. 161—174.

Faraday's investigations into the nature of electricity were available as raw material for the physicists of the day, but the fundamental knowledge for radio-technics was provided by Lord Kelvin in 1853 by his discovery of the electrical oscillation circuit. Marconi began in 1896 to convey radio telegraphy over a long distance by using vertical aerials and earth connection. Account of the developments of radio-technics. Ultra-short wave technics. Radio direction-finding. The first trials with broadcasting. Television is gaining ground.

Ericsson
LM

Ericsson Review

No 2 a
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Printed in Sweden, Esselte ab., Stockholm 1946

Automatic Telephone Exchange on the LM Ericsson System at Istanbul

E LINDSTRÖM, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

U.D.C. 621.395.343

A new exchange for 2000 subscribers on the LM Ericsson system with 500-line selectors has been put into service at Şişli in Istanbul. This exchange is of particular interest for the reason that it works in direct conjunction with automatic exchanges in other sections of the city, built earlier on the Western Electric's Rotary system. This joint traffic is operated in the same manner as traffic between the older exchanges and the registers of the one system directly operate the selectors of the other. This has been made possible by adapting the new exchange to the grouping of the Rotary system. Nevertheless, it has been possible for the most part to utilize L M Ericsson's normal mechanical designs without modification.

The contract for the new exchange was obtained against keen competition from several other telephone firms.

Formerly the telephone service in Istanbul was operated on concession by a foreign enterprise. Some years ago, however, the concession was bought up by the Turkish State and telephone operation is now carried on by the Turkish Posts, Telegraphs and Telephones Administration.

Prior to the putting into service of the new exchange the automatic local telephone network of Istanbul, see Fig. 1, consisted of three exchanges: Istanbul for 4800 subscribers, Beyoglu for 5400 subscribers and Kadiköy for 1200 subscribers. These exchanges are constructed on the Western Electric's Rotary system. The exchange at Şişli, recently brought into use, is made on the LM Ericsson system with 500-line selectors. The Istanbul local network also comprises some ten suburban exchanges, each with a capacity of from 80 to 300 subscribers. These suburban exchanges are at present operated manually. The trunk exchange of Istanbul serves about one hundred trunk lines and the most recent extension made to it was carried out by LM Ericsson.

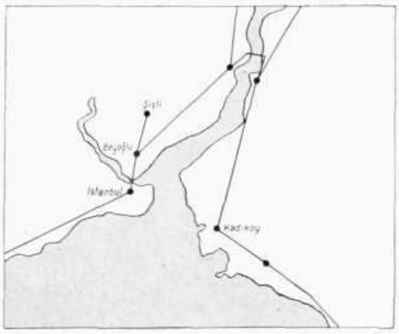


Fig. 1 X 3997

Map of the automatic local telephone network in the city of Istanbul

As the submarine cable between Kadiköy on the east side of the Bosphorus and the other exchanges on the west side is laid across the narrowest part of the strait and does not follow the shortest route between the exchanges, the junction circuits are extremely long. Thus the line distance between Kadiköy and Istanbul is about 30 km, though as the crow flies the distance is only some 6 km. Joint traffic with the suburban exchanges is carried on without manual operation at the automatic exchanges. The suburban exchanges are connected direct to the automatic exchanges, usually the nearest, and are called by two-digit numbers. Calls from the suburban exchanges to the automatic exchanges are »dialled out» by the suburban exchange operators.

Trunk traffic to local subscribers is connected direct by the trunk operators over junction circuits connected to the local exchanges and is routed over the same connecting devices as the local traffic. The trunk operators have no facility of cutting in on these circuits to offer trunk calls to busy subscribers. There are, however, separate circuits to each automatic exchange over which operators may cut in on busy subscribers and break off calls proceeding.

The New Exchange

Subscribers in Şişli were formerly connected to the exchange in the adjoining district of Beyoğlu, but the »subscriber increase» attained such an extent that the Administration found that the provision of a separate exchange for Şişli was justified. This exchange, to be made for an initial capacity of 2000 subscribers, was intended in the first place to relieve the Beyoğlu exchange in order that the latter exchange could absorb the »subscriber increase» in its own area without immediate enlargement.

The Turkish Telephone Administration, therefore, called for public tenders and after examining the tenders submitted by a number of telephone firms, including the supplier of the existing telephone exchanges in Istanbul, LM Ericsson was awarded the contract for furnishing the new plant. The contract provided not only for the equipment of the new exchange for 2000 subscribers with main distribution frames and distribution equipment for the street cables together with an air conditioning plant for the apparatus room, but also the devices necessary at the other exchanges for joint traffic and a »time-giving machine». The contract included also the erection of the material to be supplied, so that the plant could be handed over to the Administration in complete running order.

Grouping of the System

In the existing exchanges on the Rotary system, the first group selectors are connected over junction lines to second group selectors in other exchanges. The traffic to 10000 subscribers in the exchange itself is not, however, routed over second group selectors but the first group selector can select direct the third group selectors for five different groups of 2000 subscribers. The first group selector also provides a route for traffic to the special services. In the third group selector the traffic is distributed in the customary Rotary system manner to 10 groups of final selectors with a capacity of 200 subscribers.

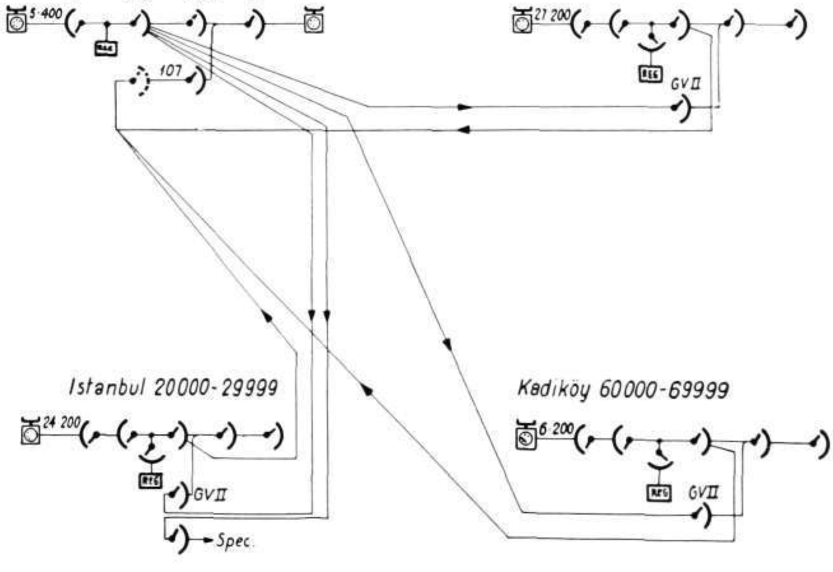


Fig. 2 X 5634

Trunking diagram for Şişli exchange and its junction lines

GV_{I}, GV_{II}, GV_{III}	group selectors
LV	final selector
REG	register
S	line finder
Spec.	special services

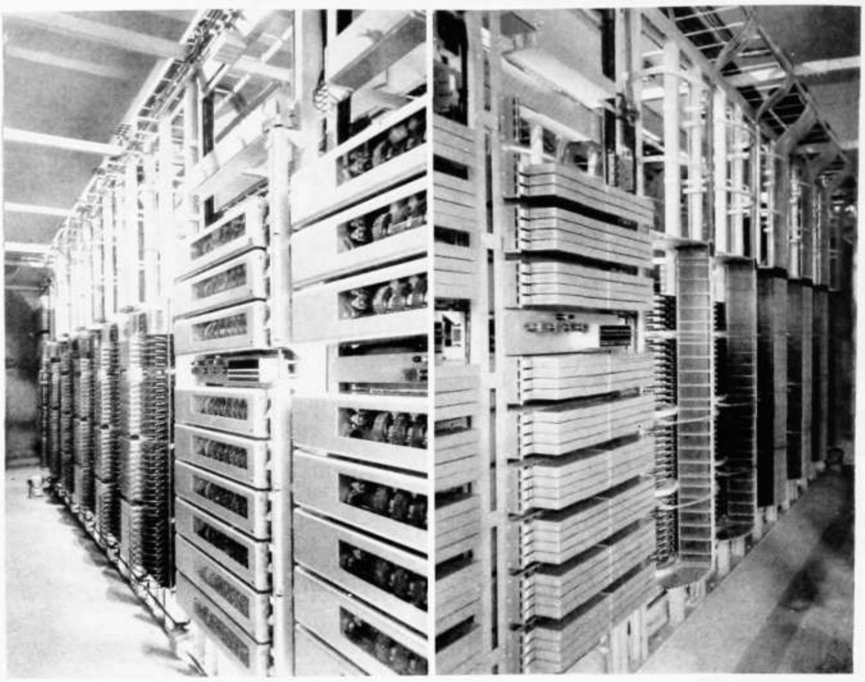


Fig. 3
Suite of racks for 800 lines
left, front; right, rear

X 5628

In the LM Ericsson system with 500-line selectors the grouping normally is such that a group selector can provide 25 routes. It would therefore have been possible to make the new exchange with only one group selector stage for the internal traffic. The first group selector would then have provided four routes for traffic to other exchanges, 20 routes for 500-line groups within the exchange and finally a route for traffic to the special services. Such a grouping, however, would have required the new exchange to be provided with registers that could route the selectors according to two entirely different discriminating systems and the incoming traffic to be connected over special discriminators in the new exchange. For this reason it was considered advisable to adapt the grouping, see Fig. 2, to the existing system, so that the registers of the other exchanges could directly operate the selectors in the new exchange. There are, however, certain differences in the grouping these being due to the differences in the capacities of the selectors employed. Thus in the new exchange there is employed only one line finder stage as against two in the older exchanges. Respecting the final selectors the greater capacity of the LM Ericsson selector has been utilized in such a way that the connections to two groups of 200 line final selectors have been combined into one group connected to final selectors with access to 400 subscribers. Moreover the new exchange has been made without register finders.

No special arrangement has been made in the new exchange for joint traffic with the other exchanges, this traffic being dealt with in the same manner as between the existing exchanges. For each of the automatic exchanges a group of junction lines in either direction is required, and in addition an extra group at the Istanbul exchange for traffic to special services. In the older exchanges the incoming traffic is led in to the second group selectors. At Şişli, where the initial installation comprises but 2000 subscribers, is has been possible for the present to dispense with incoming second group selectors, the junction lines being connected direct to third group selectors. At a future extension of the Şişle exchange, however, second group selectors will be introduced.

The manual suburban exchanges are connected to their parent exchanges by two-wire junction lines. The traffic to and from these suburban exchanges is carried on for the present over other automatic exchanges, but at Şişli there are devices for the connection of 10 direct lines from certain suburban exchanges.

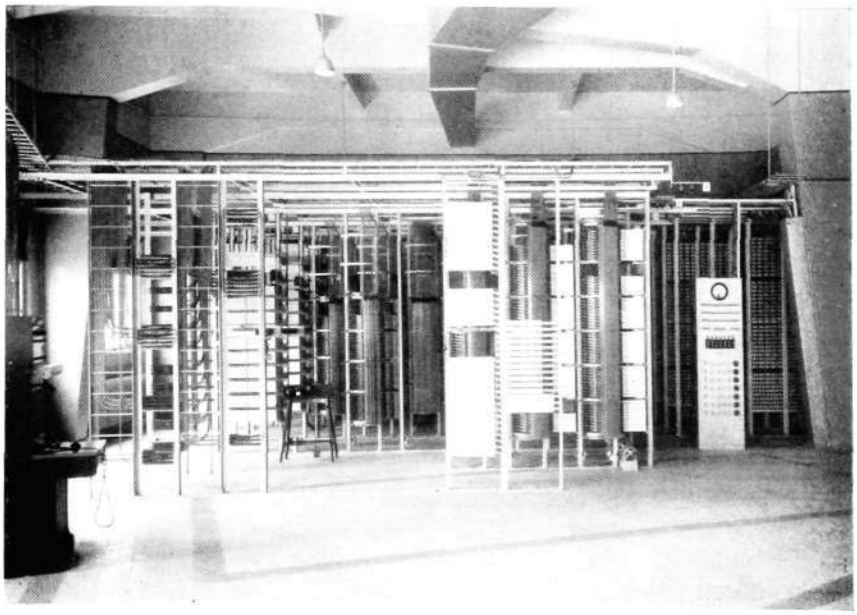
The number series *80000—89999* has been reserved for the Şişli exchange and the present stage of the exchange comprises the numbers *80000—81999*. The numbers *70—79* are destined for future manual suburban exchanges. The special services are called by the numbers *00—09* and the whole of the traffic to these is led in a single group to the Istanbul exchange, where it is distributed by special group selectors. The »time-giving» plant, now delivered and called by the figure *35*, is installed at the Beyoglu exchange, however.

Nor has the capacity of the LM Ericsson selector, 500 subscribers, been wholly utilized for the line finders, but the multiple for these, as with the final selector, has been restricted to 400 subscribers. Through this it has been possible to group the racks in suites, see Fig. 3, comprising all the connecting devices belonging to a subscriber group. In this way the exchange is given a uniform and convenient arrangement, which is naturally a great facility in maintenance. The Şişli exchange consists of five subscriber groups each of 400 subscribers, and each suite can accommodate two such groups. One of the groups contains the junction lines from manual suburban exchanges and in another it is also possible to connect P. B. X. subscribers.

At present the number of connecting circuits is 33 in four of the groups and 43 in the group containing P. B. X. subscribers. The corresponding numbers of registers are 9 and 11. The numbers of final selectors are 32 and 41 respectively. For joint traffic with the earlier exchanges of Istanbul, Beyoğlu and Kadiköy there are connecting devices for 45, 46 and 16 junction circuits in each direction, with eight circuits for traffic to special services in addition.

Mechanical Design

One might be inclined to believe that the adapting of the LM Ericsson system to another system having quite a different grouping would entail thorough redesign mechanically of the parts comprised in the system. It has, however, been found possible to use the mechanical designs occuring in the normal LM Ericsson system to a large extent unaltered. Thus the new exchange contains all the designs which are a feature of the system, such as 500-line selectors with bare-wire multiple, the LM Ericsson relay etc., but as regards the connecting diagram the new exchange works in essentials according to the principles of the Rotary system. As may be seen from the illustration, Fig. 4, externally it is hardly possible to distinguish the exchange from a normal LM Ericsson exchange of up-to-date construction.



X 5641

Fig. 4
Apparatus room

The only mechanical alteration necessary was that of the 500-line selectors, the impulsing of which had to be adapted to the impulsing system of the earlier exchanges. In the normal LM Ericsson systems the movement of the selectors from one position to another is marked by a half impulse, *i. e.*, either by a making or by a breaking of the impulsing circuit. In the Rotary system on the other hand each such movement is represented by a complete impulse, that is both a making and a breaking of the dialling circuit. The normal selectors' impulse equipment could, by a suitable adaptation of the speed, have been retained for the group selectors if only every alternate position in the controlled direction of movement of the multiple had been utilized, but in that way the group selector multiple would have been enlarged to an unnecessary extent. Moreover, it was found necessary in any case to design for the final selectors new impulsing devices which could be adapted without modification to the group selectors. Consequently all the impulsing devices on the selectors are so constructed that they give a complete impulse for each movement equivalent to a step.

The radial movement of the final selectors agreed as regards capacity with the corresponding movement in the Rotary system, so that the same numbering was retained. The impulsing devices for the rotating movement are of the same design, though the impulses are utilized in a rather different manner.

As already stated, two groups of 200 subscribers each are reached by the same final selector, enabling the advantage of the great capacity of selector to be utilized. This had to be done, however, without modification of the existing registers. The impulse cams and the impulse groups belonging to them, Fig. 5, are therefore so shaped that making of the dialling circuit is obtained both when the group is in top position and when it is in bottom position, while breaking occurs in mid-position. By simple means it is possible to have only top and only bottom impulses in the selector routing relay set connected to the register, enabling one 200-line group to be separated from the other in the same selector rack. The one group will then lie in the odd section of the multiple and the other in the multiple's even section. The prolongation thus caused in the breaking of the impulses has no adverse effect on the working of the registers.

Circuit Arrangements

In the construction of the registers no mechanical change whatever has been made. The registers are assembled in the normal manner of register selectors with mechanical winding and relays. As regards connection, however, they vary from the normal LM Ericsson system. The most fundamental differences are to be found in the shaping of the starting and dialling circuits to the selectors, and the utilization of the complementary values of the figures registered from the subscriber for the control of the selector operation. It should also be noted that selectors which are not at the same exchange as the controlling register are during operation not always restored on breaking of the control circuits from the register. They require instead a releasing current from the register, for automatic restoration.

Comprehensive new design work has been carried out also on the operating relay sets of the selectors and the equipments of the connecting circuits. This has been necessitated, among other things, by the special manner in which the operating and restoring of the selectors is controlled. It would take up too much space to discuss all the problems which arose, but some account of the facilities offered by the new system would appear to be justified. The line equipments are of LM Ericsson normal design for four-wire line-finder multiples. This construction was selected with a view to the forthcoming automatisation of the suburban traffic of the city of Istanbul, when it is possible time-zone metering will be adopted. The four-wire multiple utilizes two wires for the

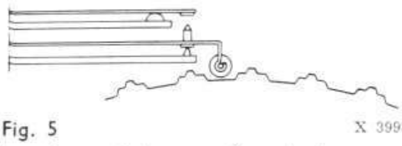


Fig. 5
Impulse contact group for selector

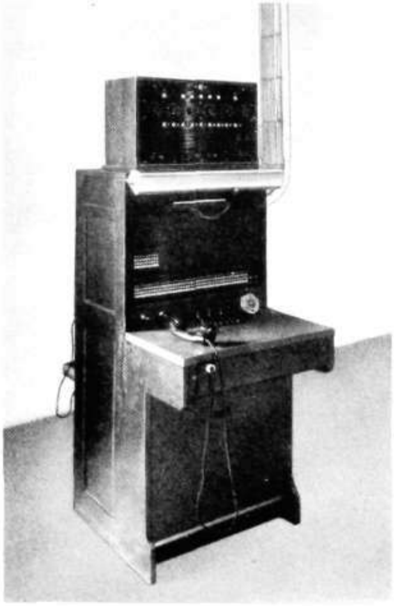


Fig. 6 X 4439
Traffic supervision position with routine test equipment

speaking circuit, one for the testing and one for the metering, the latter operation therefore can take place while the call is proceeding. The connecting circuit relay sets are so made that on a local call one metering impulse is sent out at the close of the conversation. The devices are arranged, however, in such a manner that with automatic suburban traffic a number of meterings may be taking place during the course of the call. All the connecting circuit relay sets are made for polarity reverse on the calling subscriber's line on answer from the called party. The signal thus obtained may be employed as the »encashment» impulse for prepayment coin-boxes, so that such instruments may be connected to all subscriber groups. In one of the subscriber groups the polarity reversing is mobile, *i. e.*, the polarity reverse follows the called subscriber's answering and clearing signals, thus giving complete signalling over the junction lines to manual suburban exchanges connected to this group. The current feed relays for both calling and called subscribers are to be found in the connecting circuit relay sets while the devices for the giving of ringing signals and busy signal are built in to the final selector operating relay set. Moreover the connecting circuit relay set comprises devices for the connection and disconnection of metering for traffic to the various special services.

The group selectors and the final selectors have three-wire multiples but time-zone metering impulses may nevertheless be transmitted during conversation from the junction line equipment to the connecting circuit. This is done over the test wire to the operating relay set. Concerning the operating relay sets for these group selectors and the normal final selectors there is nothing special to note, but as regards the P. B. X. final selector it may be observed that with a view to P. B. X. hunting and night connection they are made on the normal LM Ericsson system.

Special group selectors are arranged at Şişli for the incoming traffic. The operating relay sets, in addition to the operating relays for the selector, contain battery supply bridges for the local subscriber together with devices for the transmission to the calling exchange of the called subscriber's answering and clearing signals. On account of the junction circuits being two-wire this device is also utilized for the supervision of disconnection which is controlled by the calling subscriber. At the other exchanges the second group selectors for incoming traffic from Şişli are made in the same way. In view of the long distance to the Kadiköy exchange on the other side of the Bosphorus the junction circuits between this exchange and Şişli are equipped with impulse repeaters.

The traffic supervision position is an innovation in the telephone network of the city of Istanbul, but all the same LM Ericsson's normal system for this has been applied in order to benefit from the facilities for centralized and easily accessible observation of traffic offered by the register system. There is for each register a supervising strip mounted at a common observation position, see Fig. 6. By means of lamp signals in the supervising strip it is possible to follow the connections of the subscribers and from the observation position there is a facility to assist the subscriber in making connections in a proper manner and to retain defective connections for investigation.

Trunk Switching

As already stated, the trunk traffic is mixed with the ordinary local traffic. The junction circuits from the trunk exchange to the local network are therefore connected only to the line finder multiples in the nearest automatic exchange and the traffic is distributed in the ordinary manner over the automatic junction circuits to the other exchanges. In addition, there is at least one circuit from the trunk exchange to each automatic exchange for offering trunk calls to busy subscribers. At Şişli this circuit is connected to an incoming

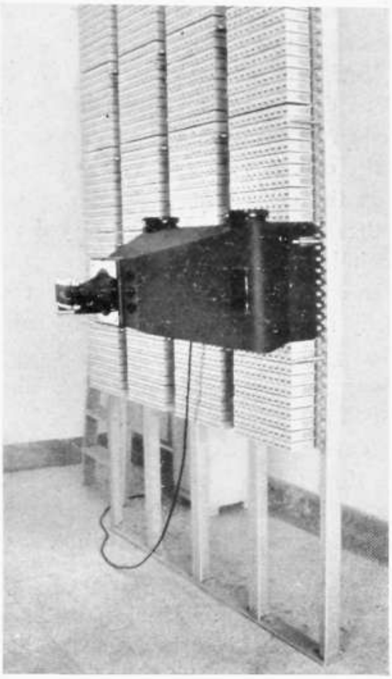


Fig. 7 X 3977
Call meter rack with camera

repeater, connected direct to a special connecting circuit. The repeater constitutes a repeating link between the two-wire junction circuit and the exchange equipments. Each subscriber group of 400 numbers has a final selector for this special traffic. Since therefore there is only one such selector per group, the hunting movement of the corresponding group selector is dispensed with. This has therefore been made as a relay group selector without multiple, thus doing without special selector racks for this small traffic. The first group selector, however, is of normal construction.

In respect of operating procedure these devices are so arranged that on call over them the operator can by means of lamp and buzzer signals ascertain the situation of the called circuit. Intrusion on a call proceeding is only done after a special cutting-in signal from the operator's position. The call may be broken by the repetition of this signal. The signalling system and the method of operation are naturally adapted in other respects to the trunk exchange.

The trunk ordering traffic from Şişli is routed over the existing ordering circuits which proceed from the Istanbul exchange.

Call Meters

There is a call meter permanently connected to each subscribers line equipment, and this, with a view to a projected multiple metering, is arranged for a speed of metering impulses approximately corresponding to the normal impulse velocity of a dial.

The call meters are mounted in separate racks and are assembled in groups of 100 meters. This grouping facilitates reading, done in this case with a special camera having built in lighting arrangements, Fig. 7. This method ensures an extremely rapid an exact reading of the meters. The manipulation of the apparatus is very simple. The camera is moved on special guides along the group of meters to be read. As the camera is in this way always located at a definite distance from the meters and the source of light gives constant illumination, the exposure is always the same. The film is changed automatically on exposure.

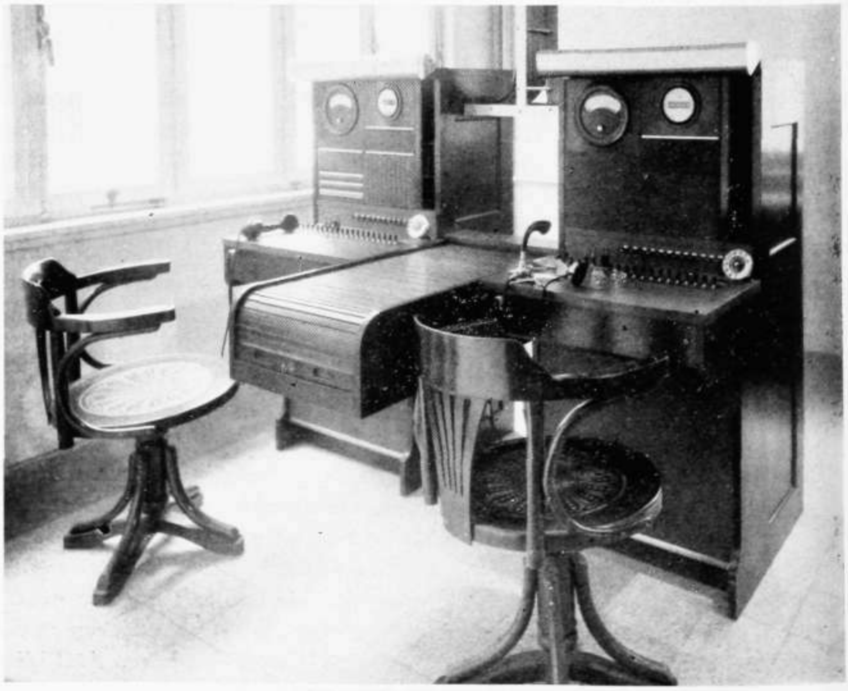


Fig. 8 X 5629
Test positions
with subscriber card index between

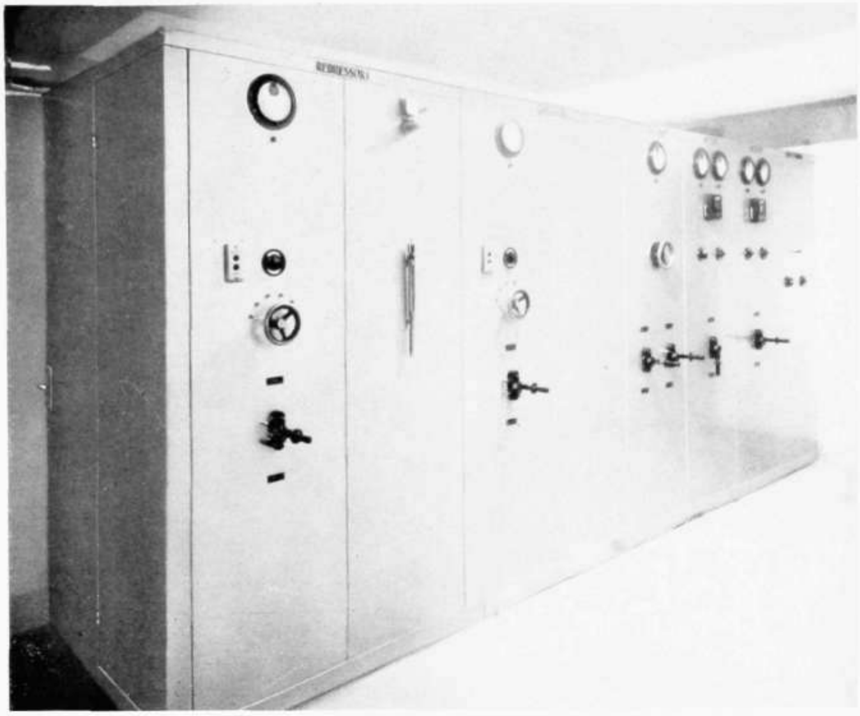


Fig. 9
Charging equipment

X 5630

This method of reading has proved exceedingly advantageous particularly in cases where debiting is entirely on the basis of the readings. The debits may be checked in a manner satisfactory both to the telephone administration and to the subscriber.

Distribution

The distribution frames are equipped with protection and test devices of LM Ericsson's normal construction, consisting of lightning arrester strips with heavy fuses, carbon protectors and heat coils on the one side and test jack strips on the other. The distribution frame equipment also comprises a test position for subscriber lines and a special test position where all the junction circuits appear. In addition to the ordinary measurements of the resistance and insulation values of the lines it is possible to check the subscribers' dials from the test position.

Subscriber lines which have been found faulty on test are connected over special cords and relay sets to the test position while repairs are carried out. Subscribers calling such a line receive a special buzzer signal, announcing that the number is out of service. It is possible, however, from the disconnected line to call the test position by means of magneto instruments to request test, re-connection for traffic and the like. Between the above two positions a cabinet for subscriber card index, Fig. 8, has been mounted.

The test positions are connected over service circuits with the fault position at Istanbul exchange, so that close cooperation may be established for fault location, testing etc.

Testing

The Şişli exchange is tested regularly by a testing device conforming in the main to that described in Ericsson Review No 2, 1938. With this apparatus all connecting devices intended for local traffic may be tested in respect of operation, checking of tones and ringing signal, and also battery supply and transmission properties. It is also possible to test the connecting devices for incoming traffic with this apparatus, but special testing instruments have been provided further to facilitate the checking of these devices.

For the supervision of the equipments for the special lines from the trunk exchange a simple test device has been made which is designed to fulfil the same duty as the trunk cord and the operator equipment in the trunk exchange. In this manner it is possible to make tests from the automatic exchange for those signals and markings that are transmitted from or received in the trunk positions.

There is besides a portable test bench for thorough individual testing of the connecting devices in the Şişli exchange.

Power Plant

The power plant consists of two 48 V storage batteries each for 1008 Ah. They are sufficiently large, however, for a final capacity of 1584 Ah. The batteries are charged by two fan-cooled metal rectifier units each of 100 A.

The instruments and operating equipment for charging are mounted on enamelled iron boards. By assembling the boards and rectifiers together as a unit there has been obtained a concentrated and easily accessible charging equipment, Fig. 9.

As an emergency spare for the rectifier unit there is a petrol engine driven unit with a capacity of 200 A. Ringing and buzzer signals are produced by two signal generators. One is driven from the city A. C. mains and the other, intended as an emergency spare, by 48 V D. C. from the exchange batteries.

The distribution circuits of the charging boards are connected in the automatic room to a distribution board. From this are distributed operating voltage, ringing current, buzzer and mains voltage for the motors to the various suites of racks. The distribution to the various panels is done by distributing devices in the suites.

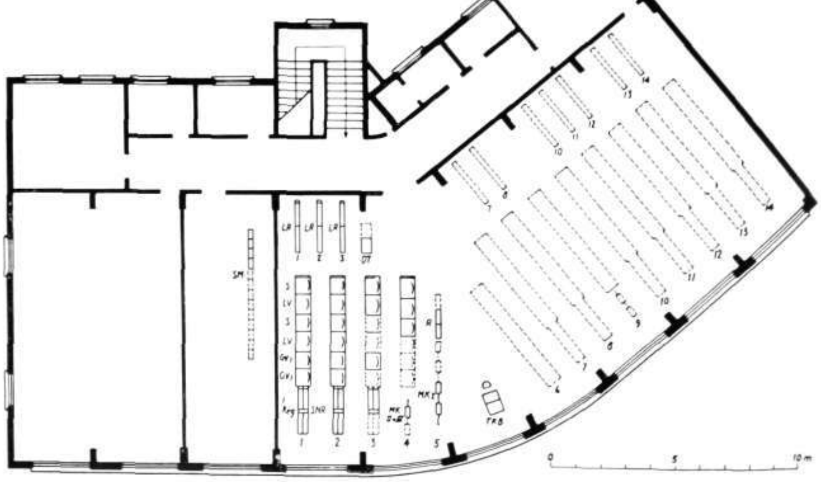


Fig. 10 X 5635

Lay-out plan of the apparatus room

DT	distribution panel
GV	group selector rack
LR	line relay rack
LV	final selector rack
MK	intermediate connecting
R	relay rack
REG	register rack
S	line finder rack
SM	*call meter rack*
SNR	connecting circuit
TKB	traffic supervision position

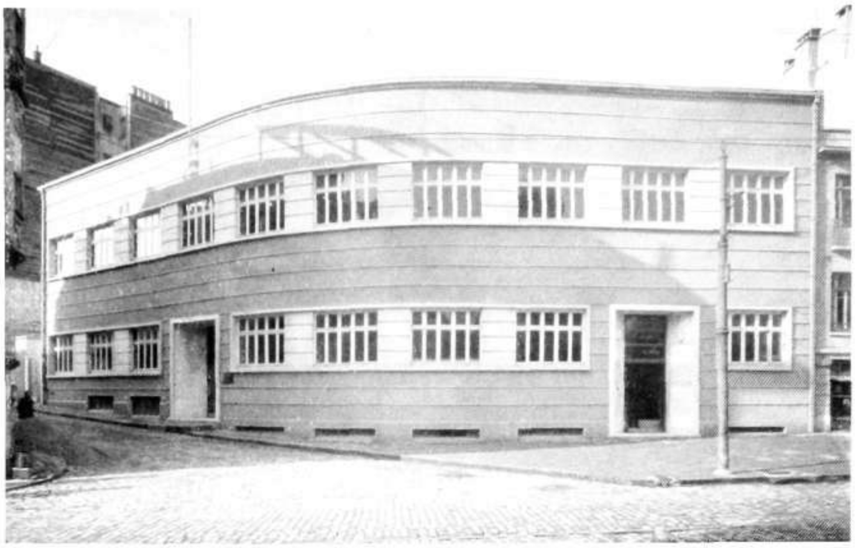


Fig. 11
Exterior of Șișli exchange

X 5632

Air Conditioning Plant

The air conditioning plant serves to maintain the humidity in the automatic exchange as constant as possible, ensuring more reliable functioning of the exchange. The plant comprises a conditioning apparatus with heating battery and oil filter for heating and cleaning the air. The treated air is discharged through an air channel which runs along the whole middle of the room and which is of such dimensions that the treated air is evenly distributed along the whole channel.

The machinery is assembled in a unit which is mounted in the ceiling, so that no useful floor space needs to be taken up. The control devices of the plant, however, are mounted at a convenient height from the floor. These devices control the humidity percentage of the air in the premises and adapt the working of the plant so that the air humidity fixed by the control devices is kept constant. Variation of the setting of the control devices enables the humidity limit to be altered to any desired level.

Lay-out

The placing of the exchange equipments may be seen in Fig. 10. The distribution frames and the test positions are located in a separate room situated right over the underground distribution chamber, enabling the cables to be conveniently led direct through the floor to their terminal points in the distribution frame. The distribution frame has been located in a separate space to avoid dust and particles of yarn detached in re-arranging the jumper wires in the distribution frame from penetrating to the automatic room where they could easily cause contact failure in relays etc. The test positions are auxiliary equipment to the distribution so that their location in the same room is obvious.

The call meters have been located in a separate room because it is desired to eliminate all possibility for unauthorized persons to tamper with these devices, on the unhampered working of which the charging of subscribers is based. This room is accessible only to those members of the staff who are responsible for the reading of the meters.

The switching equipment racks are set up in suites. Each such suite, see Fig. 3, comprises line finder, final selector, first group selector, connecting circuit relay sets and registers for 800 subscribers. There is also a line relay rack for each such row, this being mounted apart.

The row of units *3* is for the time being only half mounted. Row *4* contains two panels for incoming group selectors and one panel with internal third group selectors and moreover intermediate connections for their multiples. Row *5* comprises panels for the intermediate connection of the first group selector multiples as well as for the repeaters on the junction line from Kadiköy, the equipments for the special line from the toll exchange and various auxiliary relay sets. In the apparatus room there is accomodation for another 6000 lines. The distribution board as well as the traffic supervision board may be enlarged for this capacity without difficulty.

Time-giving Installation

The time-giving apparatus is installed at Beyoglu exchange. It is connected to the group selector multiple, thus providing good facility of extension for the connecting circuits. The machine is called by a two-digit number and gives an announcement every tenth second. Each call allows two successive announcements to be listened to, after which the call is disconnected from the machine and busy tone is given to the subscriber. Following each announcement there comes a short buzzer-tone to indicate the exact moment when the time announced occurs. This check tone is controlled by a precision clock having an accuracy of running of ± 0.5 s per 24 hours. Further particulars of the design of the machine will be found in the description in Ericsson Review No 2, 1934.

Putting the Plant into Service

The inauguration and putting into service of the plant took place on November 25, 1939, in the presence of a number of leading men of the Turkish Administration. Mr. Kadri, Director-General of the Turkish Telephone Administration, made the opening speech and connected up the exchange by breaking a pre-arranged blocking device. The switching equipment immediately came into operation and the exchange functioned from the first instant with unfailing precision. The experience obtained up to now of the operation of the new exchange has been particularly good and, despite the fact that its design is entirely different from the earlier exchanges, the joint working has functioned splendidly.

The Şişli exchange therefore constitutes a living testimony to the great adaptability of the LM Ericsson system and demonstrates that new exchanges, in telephone networks containing automatic exchanges on other automatic systems, can also be satisfactorily built with LM Ericsson's modern designs.

New Swedish Telephone Plants with 500-Line Selectors

B BJUREL, ROYAL SWEDISH BOARD OF TELEGRAPHS, STOCKHOLM

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For the automatisation of large and medium-sized Swedish telephone plants a new type of telephone exchange with 500-line selectors has been developed. This type of exchange, taken into service for the first time on the automatisation in 1943 of the Eskilstuna telephone exchange, displays several innovations in the technical equipment. Among other things it may be mentioned that the equipment for inter-district traffic has been redesigned and that the setting up in the exchange itself of trunk calls has been automatised. This article gives a description of the new exchanges.

In the Swedish telephone network there is at present proceeding an automatisation of the older manual telephone plants as well as an automatisation of traffic between the different plants. For this automatisation the smaller exchanges are constructed on the Telegraph administration's own system with crossbar selectors and practically all the large exchanges on Telefonaktiebolaget LM Ericsson's system with 500-line selectors. There are thus obtained two widely differing systems of exchanges in the Swedish telephone network, *viz:* the direct-driven crossbar system and the motor-driven 500-line selector system.

An indispensable requirement in the automatisation of the telephone network with automatic exchanges on different systems is that the inter-district traffic can be dealt with in a flexible manner, despite the different build up and functioning of the exchanges. To enable this to be done, there is required at the LM Ericsson exchanges an equipment which permits of adaptation between the signalling system used internally for the motor-driven LM Ericsson exchanges and the system with forward impulses that is otherwise used in the Swedish telephone network.

Work was begun in 1940 with a view to arriving at a new LM Ericsson exchange specially adapted for joint traffic between the exchanges in the Swedish telephone network and provided with equipment for automatic establishment of trunk calls. This work has now resulted in a new type of exchange which displays comprehensive redesigning of the equipments concerned in junction traffic exchanges and trunk exchanges. In addition, each device in the local exchange has been subjected to revision or has been redesigned.

This new type of exchange, which is supplied at present for all the larger central exchanges in Sweden, has been worked out in intimate collaboration between the Exchange Department of the Board of Telegraphs and Telefonaktiebolaget LM Ericsson. Up to november 1944 there had been ordered exchanges for 47100 subscribers, of which over half are already connected up and in service.

A brief description of the appearance of the Swedish telephone network and, in association with that, the fundamental conditions for the functioning of the LM Ericsson exchanges, together with a description of the new LM Ericsson exchanges, will be given here.

Numbering Principles etc. in the Swedish Telephone Network

A condition for the carrying out of the complete automatisation of a country's telephone network is that each subscriber in the network is allotted an absolutely distinctive number. A number system for the whole of the Swedish telephone network was worked out at an early stage and this has been followed in the automatisation now proceeding. According to this number system the country is divided up into some hundred different areas, called network groups. In each such network group the subscribers are normally allotted 5-figure and in a couple of network groups 6-figure directory numbers. The different network groups in a country have been allotted routing numbers, usually 3-figure but in some cases 2-figure.

Thanks to this number system, for all traffic in one's own network group one needs only dial the directory number of the wanted subscriber. If, however, it is desired to establish a call to a subscriber in another network group, that network group's routing number is first dialled and, when the new connecting tone has been obtained, the wanted subscriber's directory number. To distinguish the routing numbers from the number series of the originating group it is intended in the future in certain cases to have the routing number preceded by a zero as a special marking figure.

As traffic between the network groups is established by means of the directory numbers, the technical devices at the exchanges must be able by means of these numbers to connect the calls both to the correct exchange in the network group and to the correct subscriber in the exchange concerned. In order that the technical equipment to do this shall not be too complicated the two first figures in the directory number have been allotted as exchange routing numbers. The other figures in the directory number constitute the subscriber's real number in the exchange.

In an automatic system with the number system outlined above there are obtained three main types of automatic connections, *viz.:* the purely internal connections, connections between exchanges in the network group itself, and finally connections between exchanges in different network groups.

To establish automatic inter-district connections, registers are used in the Swedish telephone network. The main reason for choosing registers was that these permit a shaping of the automatic telephone network that is independent of the number series used. For the purely local traffic, however, registers are used only at the LM Ericsson exchanges.

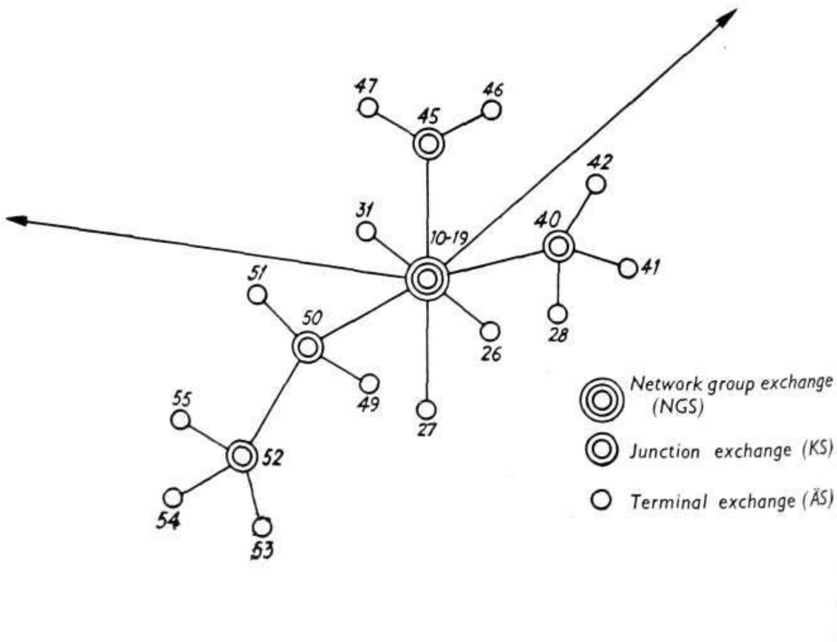


Fig. 1
Network lay-out

X 6016

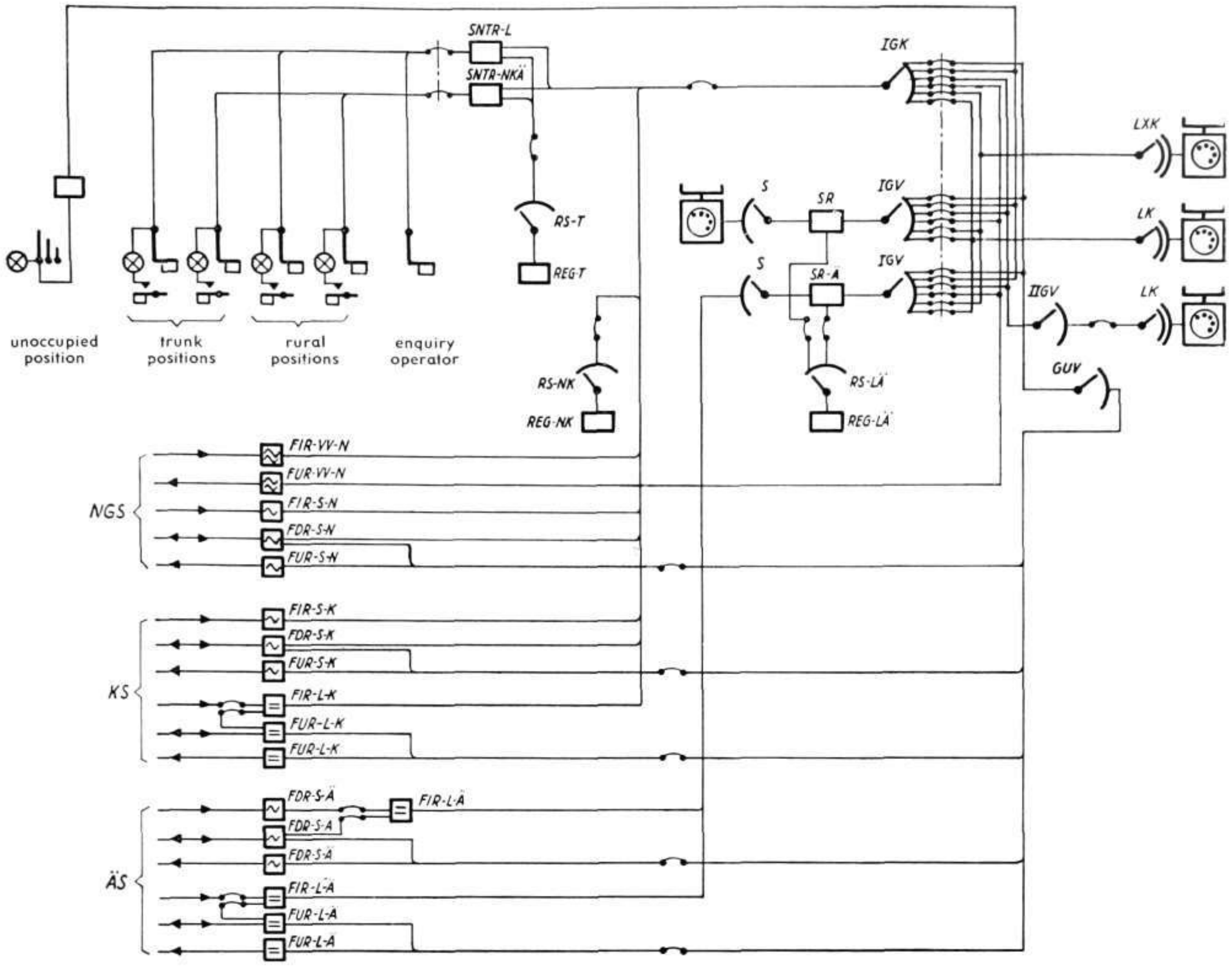


Fig. 2 X 7363

Traffic routes lay-out

FIR-L-K FIR-L-Ä FUR-L-K FUR-L-Ä	relay repeaters for incoming and outgoing junction circuits; repeaters work with D.C. signals
FIR-S-N FIR-S-K FDR-S-N FDR-S-K FDR-S-Ä FUR-S-N FUR-S-N	relay repeaters for incoming, two-way and outgoing junction circuits; repeaters work with impulse sigrals
FIR-VV-N FDR-VV-N	relay repeaters for incoming and outgoing junction circuits; repeaters work with A.C. signals with 50 c/s and 150 c/s frequency
GUV	group selector for outgoing inter-district traffic
IGV, IGK	first group selector
IIGV	second group selector
KS	traffic with junction exchanges
LK	final selector
LXK	final selector for subscribers with more than one line
NGS	traffic with network group exchanges
N, K, Ä	supplements to designations of connecting devices to indicate that the devices concerned are intended for traffic with another network group exchange, junction exchange or terminal exchange
REG-LÄ	local exchange register
REG-NK	junction traffic exchange register
REG-T	operator's register
RS-LÄ	register finder
RS-NK	register finder
RS-T	register-finder
S	line finder
SNTR-L	connecting circuits for establishment of trunk traffic
SNTR-NKÄ	connecting circuits for establishment of trunk traffic
SR	relay set for line finder
SR-Ä	relay set for line finder
ÄS	traffic with terminal exchanges

A typical picture of the traffic routes occurring in an automatised network group is shown by Fig. 1. A characteristic feature is the star-shaped network that goes out from the central network group exchange and which connects this with the different junction and terminal exchanges of the group.

From this network group map the broad lines can be seen of the work to be done by the central network group exchange on the development of completely automatic traffic in the group. The exchange, here assumed to be an LM Ericsson exchange, must, in addition to purely internal connection processes, allow of the establishment of calls between subscribers connected to the exchange itself and subscribers connected to any exchange whatever in the exchange's own network group. Besides these connections, the exchange must also deal with calls between different exchanges in the network group itself and handle all outgoing and incoming traffic with other network groups. In addition it must be able to act as intermediary for traffic between outside network groups.

The Traffic Route Lay-out of the Exchange

The traffic route lay-out of the new type of exchange, as shown by Fig. 2, gives a good picture of the general build up and properties of the plant. An account of the build up of the exchange and the broad lines of its functioning is given therefore with direct reference to this traffic route lay-out.

The Local Exchange

The traffic routes of the local exchange have largely the well known appearance of the LM Ericsson system. Each subscriber is connected both to the multiple in a 500-line finder *S* and to the multiple in a final selector *LK* with the same capacity. Between the finder and the final selector there is usually at least one group selector step *IGV*. Normally not more than 20 final selector groups are connected to this group selector step, which has 25 exits. This means that the maximum capacity of the local exchange will, with one group selector step, be 20 × 500 = 10000 numbers. In the event this capacity does not suffice, the second group selector *IIGV* is connected to exits in the first group selector, whereby there is obtained in the local exchange capacity an increase of 10000 numbers for each fresh exit in the first group selector. For the outgoing automatic traffic there is employed one or more exits in the first group selector. These exits are usually connected to a special group selector *GUV* in the junction traffic exchange but they can also be connected direct to large outgoing routes.

The functioning of the local exchange is broadly as follows. On call from a subscriber the finder *S* starts and connects the subscriber to the automatic exchange. The starting of the finder is dealt with as usual by the individual line equipment of the subscriber. To connect the subscriber, the finder first executes a rotating movement to hunt for the right multiple frame and then a radial movement to connect the finder's wiper to the subscriber's line in the frame. Immediately this connection has taken place the relay set *SR* of the finder starts a register finder *RS—LÄ*, which connects a free register *REG—LÄ*. The register, which answers with dialling tone then establishes the required connection in agreement with the number received.

The finder relay-set *SR* shown on the traffic route lay-out contains in this type of exchange the requisite current feed relays etc. for all internal connections, so that no special connecting circuit relay-set is needed. It should be observed here that there is comprised in the finder relay-sets a time checking device which breaks calls which remain connected owing to only one clearing signal. With such a breaking the finder remains stationary and marks the A-subscriber of the call in the event it is the B-subscriber who has not replaced his handset. The equipment has been arranged this way with the idea that it is the A-subscriber who should be identified.

The register equipment of the local exchange, described in more detail below, constitutes a novelty for the LM Ericsson exchanges. The registers in the new exchanges are combined local and intermediate registers. Each register thus allows of the routing of both purely local connections and intermediate district connections.

In case the register receives an internal number it sets the selectors to the correct 10000s, 500s, 20s and unit in the 20s, i. e. to the correct line in certain multiple frames, in full agreement with the principle for the 500-system.

If, however, the register receives numbers applying subscribers at other exchanges the connections are established on the following principles. On call to a subscriber connected to another exchange in the same network group, the register first routes the connection on to the called exchange. Then the register repeats the actual subscriber figures by means of forward impulses which directly actuate the called exchange selectors. By means of reswitchable connections in the registers it is possible to fix the traffic routes in the network group itself in a manner suited to the shaping of the network. On call to a subscriber in another network group, the register first routes the connection on to the head exchange of the network group over the traffic routes that have been fixed as suitable. The register then transmits the directory number to a register in the called network group, which takes over the further routing on to the correct exchange and subscriber.

Another novelty in the local exchange is the register finder *RS*. This register finder, which has the purpose of concentrating traffic from the connecting circuits to the registers, has the possibility of handling calls from 100 different connecting circuits to a joint working register group of 11 registers. The 100 connecting circuits can be selected in any way from all the local exchange's connecting circuits because of the intermediate connection which, in accordance with the traffic route lay-out, exists between the connecting circuits and the register finders. The choosing of just 11 registers for each register group is due to the fact that the register traffic from 100 connecting circuits corresponds to a maximum of 11 registers.

There is also connected to the local exchange register equipment the incoming traffic from the terminal exchanges directly under the network group exchange. As the terminal exchanges have no registers, calls from these will to a large extent be similar to calls from local subscribers. The register finder's connection of traffic from the terminal exchange circuits, often little employed, is valuable.

The Junction Traffic Exchange

The junction traffic exchange has led to it lines from exchanges in its own network group and lines from other associated network groups. The different junction circuits are connected in these exchanges to relay repeaters that deal with the transposition between the internal signal system of the exchange and the signal system employed for the circuit concerned.

A novelty in the junction exchange is that the circuits from other junction exchanges and outside network groups are connected direct to the exchange equipment without going over intermediate call finders for the incoming traffic and that the repeaters of these circuits are built together with the requisite connecting circuit equipment. On call on these circuits, the repeaters themselves therefore deal with calls by registers, furnish the necessary current feed for traffic to the LM Ericsson exchange, and so on. This connecting principle, not employed previously, provides several advantages. One advantage is that on call the connecting process is not delayed by any mobile connecting device in the form of finder or the like. Another essential advantage is the simplification of the maintenance that is obtained when the finder is dispensed with and the relay repeater of the circuit is built together with the exchange connecting circuit. As the circuits from the junction exchanges and the outgoing network groups are normally relatively well utilized the taking away of the finder does not mean any worsening of the economy of the plant.

The registers *REG—NK* in the junction traffic exchange are, like the registers in the local exchange, combined local and intermediate district registers of new design. The number series received in the junction traffic exchange registers apply either to subscribers connected to the central LM Ericsson exchange or subscribers connected to exchanges inside or outside the network group. If the calls refer to subscribers of the LM Ericsson exchange or of any exchange in the network group the connecting process will be largely the same as described above for the local exchange. If an outside network group is called the process at the junction traffic exchange will be as follows:

On call from a junction exchange circuit to an outside network group, the register at the junction traffic exchange receives only the called network group's routing number. After it has with the guidance of this number carried the connection forward to the called network group, the register is disconnected immediately. The subscriber who gets fresh dialling tone from the register in the called network group then dials the wanted directory number direct to this register.

If call to another network group comes in over a network group circuit, i. e., if transit network group traffic occurs, then the junction traffic exchange register only sets the circuits at its own exchange, after which it is disconnected.

The connection of the different junction circuits to the register equipment is done over register finders of the same design as are used in the local exchange. All outgoing traffic from the junction traffic exchange is connected either direct over exits in *IGK* or via *IGK* over a group selector step *GUV*.

Trunk Call Establishing

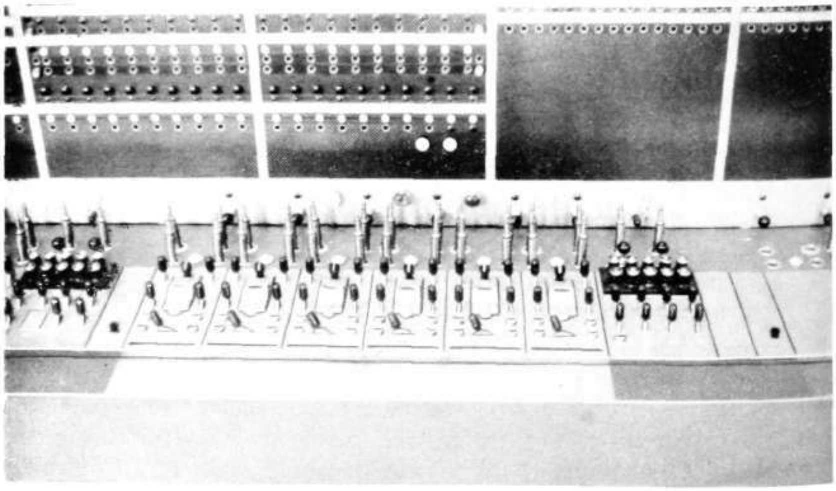
After automatisation of the local traffic at the smaller exchanges, it is not advisable from the economic point of view to retain operators at the small exchanges merely for trunk traffic. As an obvious measure therefore the telegraph administration has chosen to handle trunk traffic to the rural switchboards direct from the trunk positions of the larger exchanges. For this purpose there have been arranged at the larger exchanges operating devices which allow of automatic establishment of trunk traffic to the rural switchboards.

The new equipment worked out for this purpose for the LM Ericsson exchanges is seen on the traffic route lay-out. It comprises connecting circuits *SNTR—NKÄ*, operator register *REG—T* with register finder *RS—T*, first group selector *IGK* and outgoing group selector *GUV*.

When connecting trunk calls to an automatic rural switchboard the operator after visual testing connects her operating equipment to a disengaged connecting circuit *SNTR—KNÄ*. This circuit is then connected immediately to an unoccupied register over the register finder. The registers for operator traffic are made for momentary setting with keyset. The operator therefore can after receiving buzzer tone rapidly tap out the wanted number on her keyset. Otherwise the registers are largely constructed with the same traffic facilities as the other types of register in the exchange. After the register has carried out the establishment of the desired connection, the operator by means of her operating equipment can send out via the connecting circuit *SNTR—NKÄ* the signals required for trunk operation.

The above-described equipment, mainly intended for establishment of trunk traffic to subordinate switchboard exchanges, also provides for establishment of semi-automatic trunk traffic to other network groups.

A new feature in the LM Ericsson exchange here described is the establishment at the subscriber's exchange of trunk calls, which were not automatised formerly at the central exchanges. The equipment worked out for this purpose is also seen on the traffic route lay-out illustrated.



X 6019

Fig. 3
Trunk operator's position

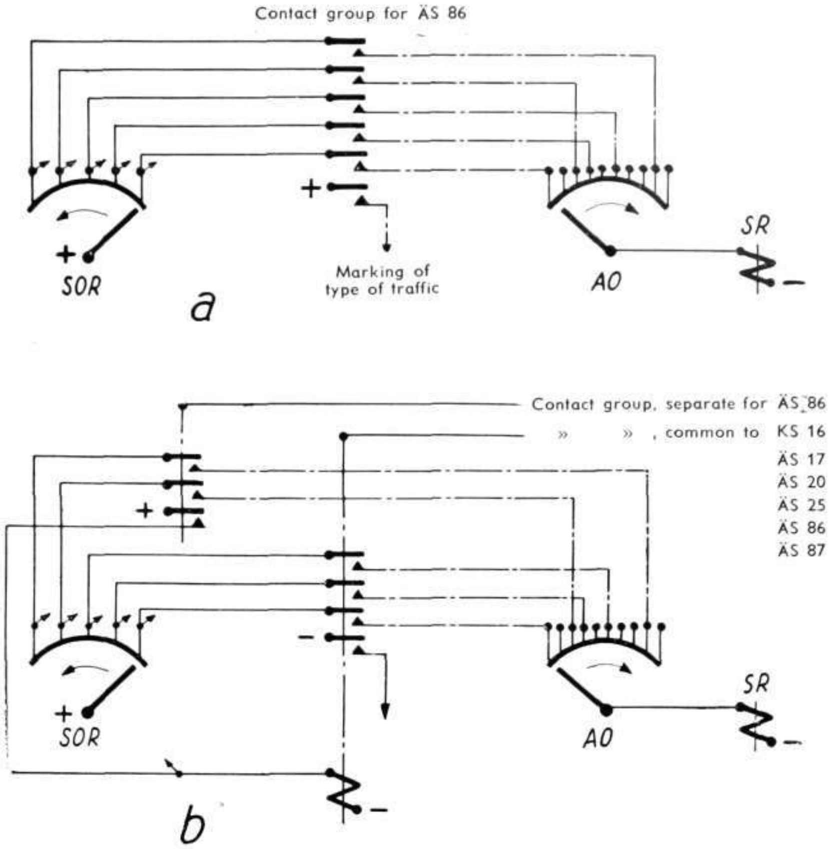


Fig. 4
Diagram of translation circuits
a old register, b new registers
AO accounting devices
SOR series switch
SR stop relay

For this automatic trunk call establishing there is used a separate equipment comprising connecting circuits *SNTR—L*, register *REG—T* with register finder *RS—T* and group selector *IGK*. However, the final selectors *LK* for ordinary subscribers and *LXK* for subscribers with more than one line are common for local and trunk traffic. In view of this, these final selectors have been made according to the broad principles which apply to all automatically handled trunk traffic in Sweden. They allow therefore breaking of local calls, trunk call marking and re-ringing. In addition it is possible with these new final selectors to arrange local or trunk queues to any subscriber whatever in the 500-line selector exchange.

In the establishment of trunk calls over the above equipment the process of operation will be exactly the same as when establishing trunk calls to a subordinate exchange. The appearance of the trunk operator's operating devices at an exchange with automatic trunk establishment is shown in Fig. 3.

The Exchange Register

Besides what has been said in connection with the traffic route lay-out respecting the registers, there should be given something regarding the principles and build up.

Principles

In combining the local and inter-district registers to a common register it might be expected that the result would be a fairly complicated and expensive register. Thanks to the employment of crossbar selectors for the building up of the different supervisory and translation circuits and to new principles for the build up of the register's translation circuits, this combining has proved economically justified.

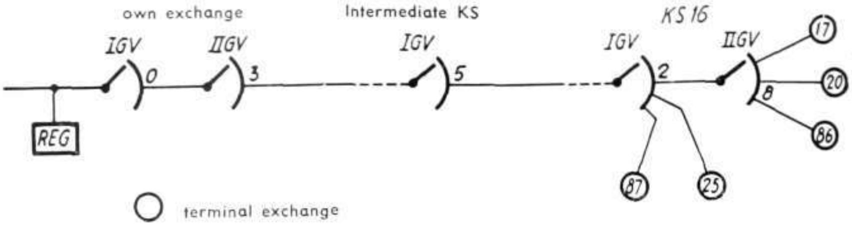


Fig. 5 X 6018
Traffic route lay-out to the translation circuits shown in Fig. 4

IGV	first group selector
IIGV	second group selector
KS	junction exchange
REG	register

Without too much detail a brief account is given below of the difference between the old principles and those now used for the build up of the free translation circuits.

For routing a connection over a desired number of selector steps, each of which is to be capable of any way of setting, there is always used in the older inter-traffic registers a definite contact group corresponding to the routing number for the circuit route. Over make contacts in this group there were built up the translation paths which controlled the setting of the different selector steps. This principle required a large number of contact groups in each register, as for practical reasons it was often necessary also to allot contact groups to certain vacant number series. Seeing that the contact groups must have a number of makes corresponding at least to the maximum number of selector steps on one and the same traffic route the registers were space-consuming and expensive. The principle of the old registers may be seen in Fig. 4, where *SOR* is a series switch which connects in the translation paths of the selector steps in their turns over the said contact group. *AO* is a device which synchronously follows the setting movements of the different selectors and stops each selector when a translation path under tension is encountered.

In the new registers there is allotted, according to Fig. 4, a large common contact group for all those exchanges which jointly use a certain suitable portion of the traffic route. In addition there is allotted a small separate contact group for each individual exchange. Over the makes of the large contact group are directed those selector steps which belong to the common traffic route of the exchanges and over the separate contact group the selector steps which go on from the common traffic route to the wanted exchange. By the introduction of this principle together with new principles for the disposition of the crossbar selectors in the registers, it has been possible to decrease the number of contacts for the build up of the translation paths to half of those previously required.

A picture of the traffic routes corresponding to the translation paths in Fig. 4 is given in Fig. 5.

Connecting-up Time

The new registers make possible very rapid connecting-up of all inter-district connections. This is due to the fact that the first registers connected are always able themselves to route the inter-district communications so that no time-consuming transfer of figures to other registers needs to take place. The rapidity attained with the new registers is particularly valuable for the operator's establishment of calls to subscribers outside her own exchange.

Mechanical Build-up

The fitting of the registers in racks may be seen from Fig. 6. The figure also shows the register finders belonging to the register rack.

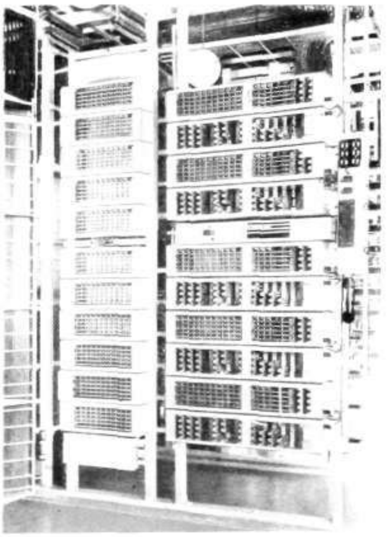


Fig. 6 X 4293
Register and register finder rack

As may be seen in Fig. 7, the registers have been divided into two separate units. The one part contains relays and the other part comprises chiefly a

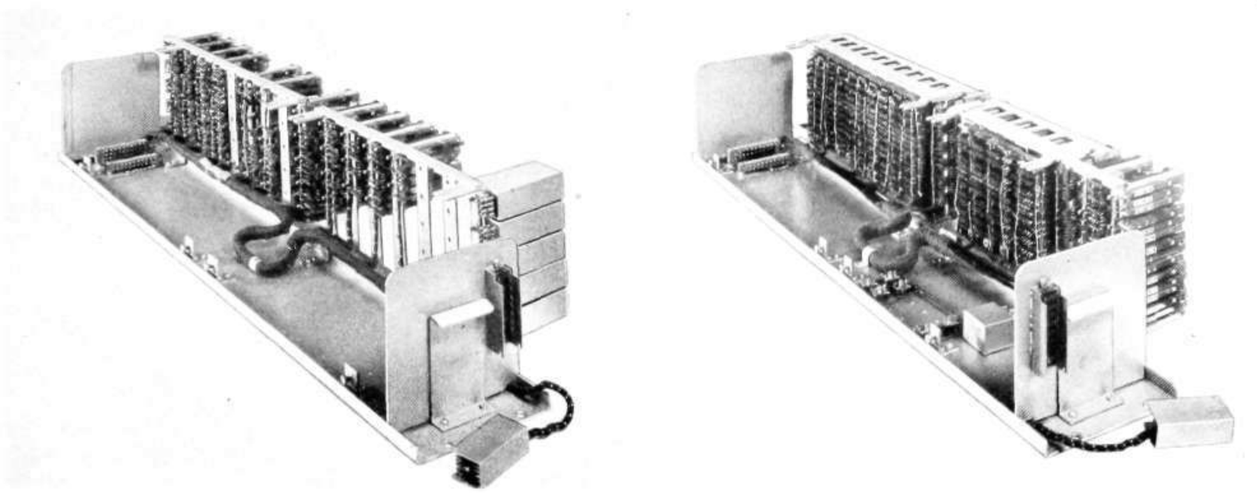


Fig. 7 X 7364

Register

left, with relay gate swung up; right, with crossbar selectors swung up

large and a small crossbar selector. The relays and the crossbar selectors are shown in Fig. 7 swung up in the way necessary for re-connection, *e. g.*, in conjunction with traffic re-organisations and the like.

All contacts in the register, as indeed in the whole exchange, are twin contacts, which is very important in respect of operating reliability and maintenance.

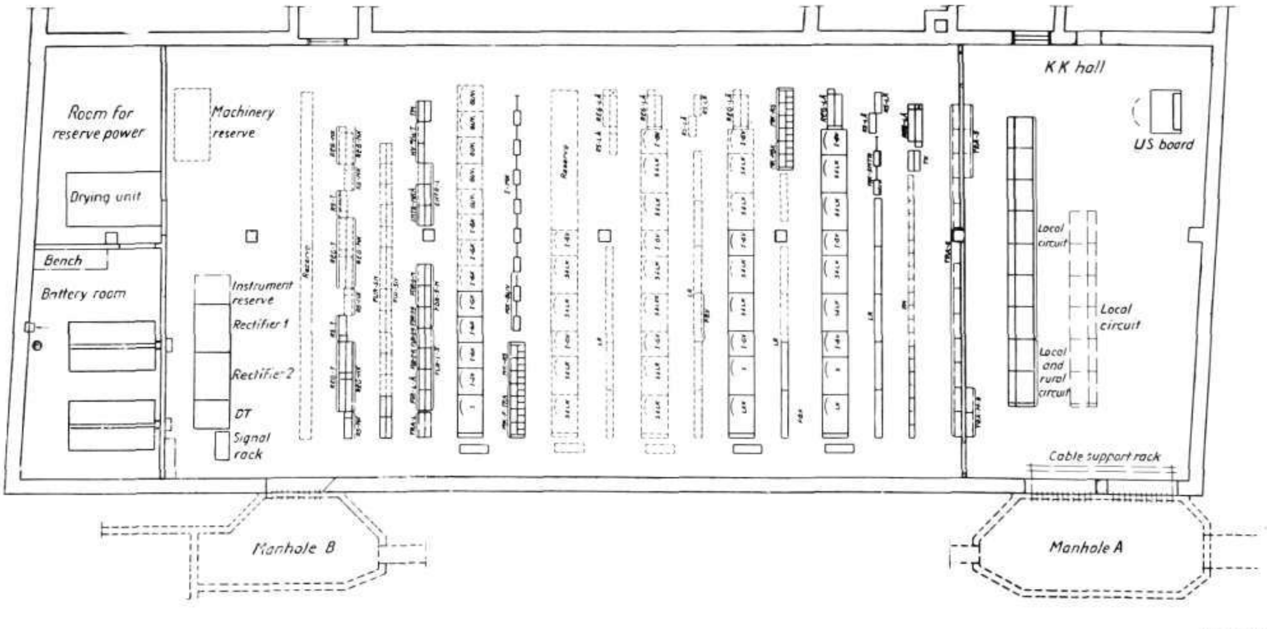
Traffic Supervision

A characteristic feature of all register operated systems is the good possibility of supervision obtainable via the registers. In the new exchanges, on account of the combining together of the local and inter-district registers, it has been possible to arrange the supervisory devices in a simple manner.

As was formerly the case, the supervision in the new exchanges is carried out in a special supervisor's position. Via this position the supervisor can connect herself to any register whatever in the whole exchange. On a special illuminated board in the supervisor's position every figure dialled by a supervised subscriber is marked. The figures can be transferred to this illuminated board even if the supervisor was not connected in to the register during the registering of the figures. After the register has completed its functions, the supervisor can remain connected and follow the call established for any length of time. In the event of fault both the register and the occupied selectors can

Fig. 8 X 7418

Lay-out plan



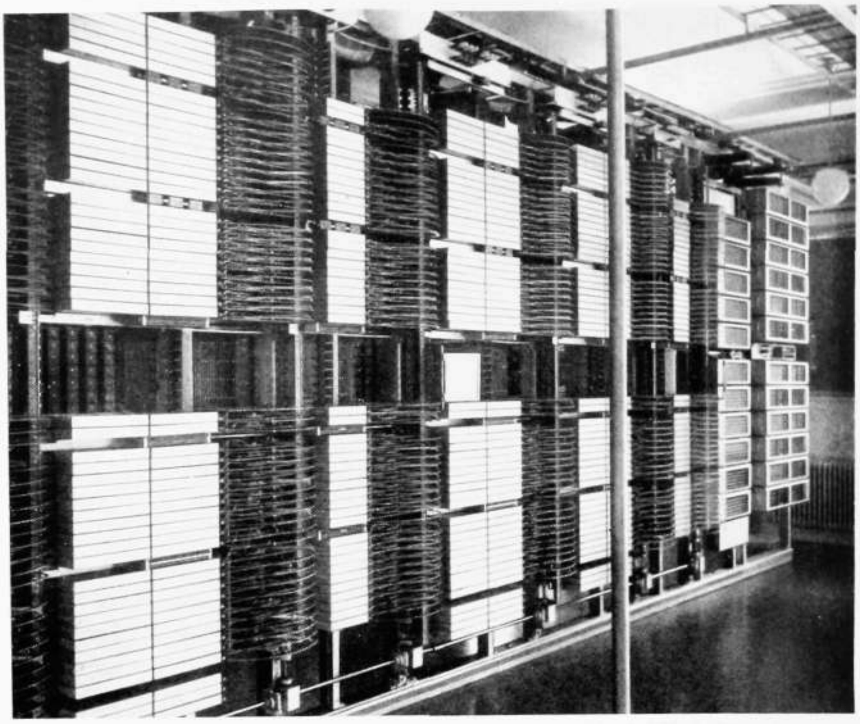


Fig. 9 X 6207
Bay of racks with selectors, register, finders and registers

be locked in the positions taken up, which may be of value in fault localizing. The supervisor is also able to give assistance to subscribers who are not able to operate their instruments properly.

In addition to this supervision by the supervisor, a certain supervision of all connecting processes can be carried out by the registers themselves. This supervision consists in the registers signalling unnecessarily long register occupation to the supervisor's position and by means of blocking buzzers informing calling subscribers immediately shortage of junction circuits to a wanted exchange occurs. If through lengthy occupation of a register there should arise a shortage of registers the register is disconnected automatically and the subscriber to blame or the incoming line is connected direct to the connecting circuit. The above-mentioned blocking tone is sent out on shortage of rural circuits only after the time of waiting in a certain selector step has exceeded 10 s.

Rural Circuit Relay Repeaters

For joint traffic between different exchanges the requisite operating signals are transmitted in the Swedish telephone network according to three different signal systems. For circuits not to be phantomed there is used purely D.C. signalling and for circuits to be phantomed either current impulse signalling or A.C. signalling with 50 and 150 c/s frequencies.

For the new LM Ericsson exchanges modernized repeaters for these three signal systems have been devised. These relay repeaters have been equipped with devices for a particularly complete supervision of the traffic.

Special time supervision devices have been arranged in the repeaters for disconnecting those connections which, because of failure to clear on the part of one subscriber, remain connected after the close of the conversation. In addition to this time supervision device, all outgoing repeaters have been provided with a fault indicating device, which for every call checks that the circuit and its connecting devices at the called exchange are in good order. In the event of fault, the circuit is blocked automatically and alarm sent out from the faulty circuit's repeater. The principles for this fault indicating device were worked out at the Exchange Department of the Telegraph Administration in conjunction with the general Swedish rural automatisation.

Call Metering

The repeated call metering employed in the Swedish telephone network for debiting automatic connections is done in the new exchanges largely in the same way as in the old. The metering unit, which normally belongs to the connecting circuit's outgoing relay repeater is connected in therefore by the register in cases where this is to be done. In order to ensure proper connecting of the metering unit the connecting of the unit is checked in the new type of exchange by means of a special received signal to the register.

The relay repeaters for the outgoing network group traffic have for the new exchanges been constructed with the idea that it should be possible some time in the future to supplement them with metering units for several different rates. The setting for the correct rate would in this case be done by the register by means of a special rate figure. This facility of differentiated charging is not yet in use, as the network group traffic is handled at present by direct circuits between the different network group exchanges.

Automatisation of the Åbo Telephone Network

E LINDSTRÖM, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

U.D.C. 621.395.343

The Åbo Telephone Association which handles the telephone service of Åbo and neighbourhood, commissioned Telefonaktiebolaget L M Ericsson in July 1938 to deliver and erect an automatic telephone exchange for the town of Åbo and a manual toll exchange for joint working with adjoining toll exchanges.

The plant, according to contract, was to be handed over in working order before the close of 1940, but owing to international developments in which Finland was involved before delivery was completed, the work was considerably delayed. The handing over, which took place on 4th July, 1942, coincided with the Åbo Telephone Association's 50 year jubilee.

The telephone service in Finland is distributed over a large number of separate undertakings. Trunk traffic in the country is operated by the Finnish Board of Posts and Telegraphs, which also owns a number of local networks. Most of the local and rural networks, however, are owned by private undertakings or telephone associations, though these collaborate closely with the Board of Posts and Telegraphs on technical questions. This collaboration is naturally of extremely great importance, particularly as regards new constructions to provide good conditions for effective joint traffic between the different undertakings. This importance is still further increased when the automatisation of the rural network grows in extent and the technical appliances thereby become more complicated.

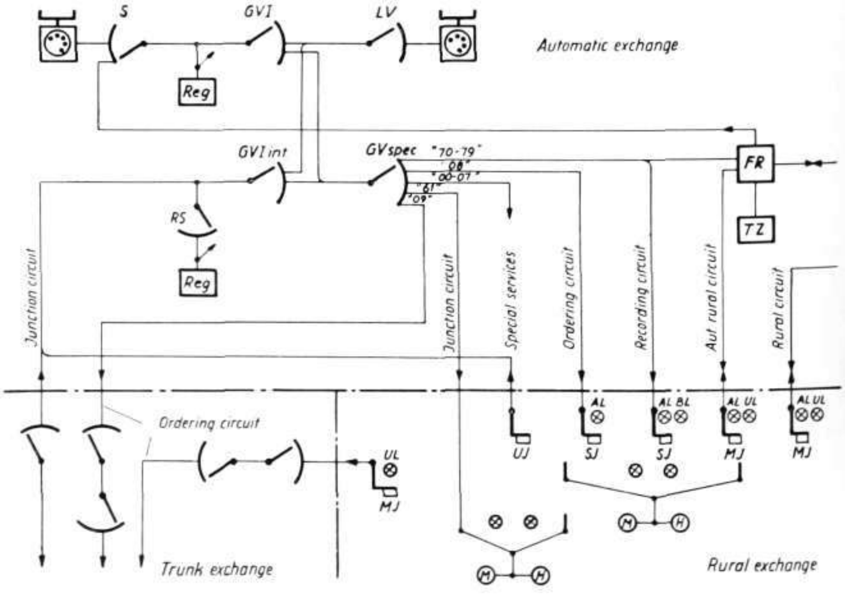


Fig. 1 X 6220

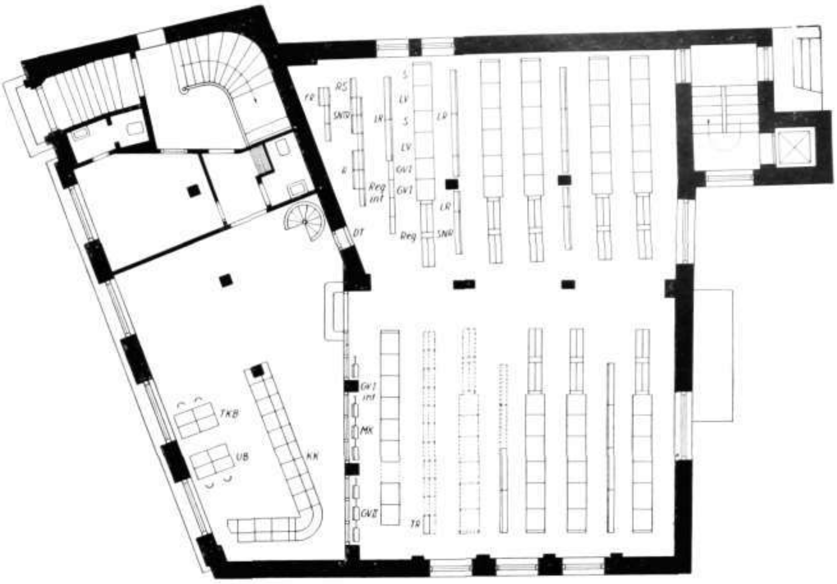
Distribution diagram for the telephone exchange at Åbo

AP	calling lamp
FR	rural circuit repeater
GV	group selector
H	telephone receiver
LV	final selector
M	transmitter
MJ	multiple jack
Reg	register
RS	register finder
S	line finder
SJ	answering jack
TZ	time metering unit
UJ	junction jack
UL	busy lamp

Fig. 2 X 5875

Lay-out plan of room for operator's positions and apparatus

DT	distribution board
FR	rural circuit repeater
GV	group selector
KK	main distribution frame
LR	line relays
LV	final selector
MK	intermediate distribution frame
R	rural circuit relays
RS	register finder for SNTR
Reg.	local register
Reg. int.	trunk register
S	line finder
SNR	local connecting circuit
SNTR	trunk connecting circuit
TKB	traffic supervisor's position
TR	relay for time-giving machine
UB	test desk



Developments in the domain of telephony in Finland are great and, especially in respect of traffic intensity very outstanding results can be shown. According to the official statistics in Europäischer Fernsprechdienst for 1940 there are handled on the average 66 local calls per inhabitant per year for the whole country, and for trunk traffic the corresponding figure is 14.7. In comparison with other countries this means that Finland comes fifth and third among the nations regarding intensity of local and trunk traffic respectively, and expansion seems to be proceeding despite the abnormal conditions prevailing in recent years.

The new automatic exchange at Åbo is the largest of a long line of LM Ericson plants in Finland; it takes the place of a manual exchange with automatic distribution, previously delivered by LM Ericsson. It was in July 1938 that LM Ericsson, against keen competition from other telephone suppliers, received the order to build the new telephone plant. According to the contract this was to consist of an automatic telephone exchange for 8000 numbers, a manual rural exchange for 90 lines, the requisite equipment for joint traffic with the the State trunk exchange and automatisation of the junction circuits to ten nearby rural exchanges. The delivery included 4000 telephone instruments as well.

In view of the complication of the building programme the period required for delivery was relatively long. There were available new premises for more than 5000 numbers of the new equipment. The remainder, 3000 numbers, were to be mounted in space taken up by selector equipment for the old exchange. The erection had therefore to be spread over two stages.

In projecting the plant it was estimated that the number of subscribers at the time of switching over the first stage would be about 4500, so that all subscribers could be switched over at one time, the old premises evacuated and reconstructed and the installation of the second stage carried out. On account of the long postponement of the building programme and the abnormally heavy increase in subscribers, this programme could not be carried out. Instead the problem arose of conveying the full traffic during the concentration of the old exchange equipment in a smaller space, so that room could be made for the automatic equipment required to cover the increase in subscribers. Out of consideration for the subscribers, it was not thought advisable to make the change-over in two stages. The old exchange equipment consisted mainly of selectors, which obviously complicated its removal as there was no reserve equipment available.

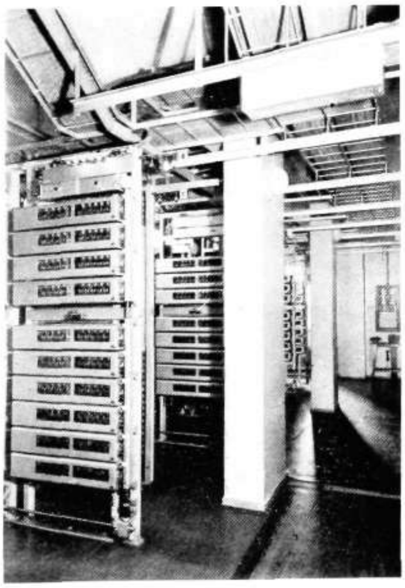


Fig. 3 X 4183

Interior of apparatus room at Åbo telephone exchange main passage

main passage

In this way the first building stage was enlarged to comprise 7000 numbers.

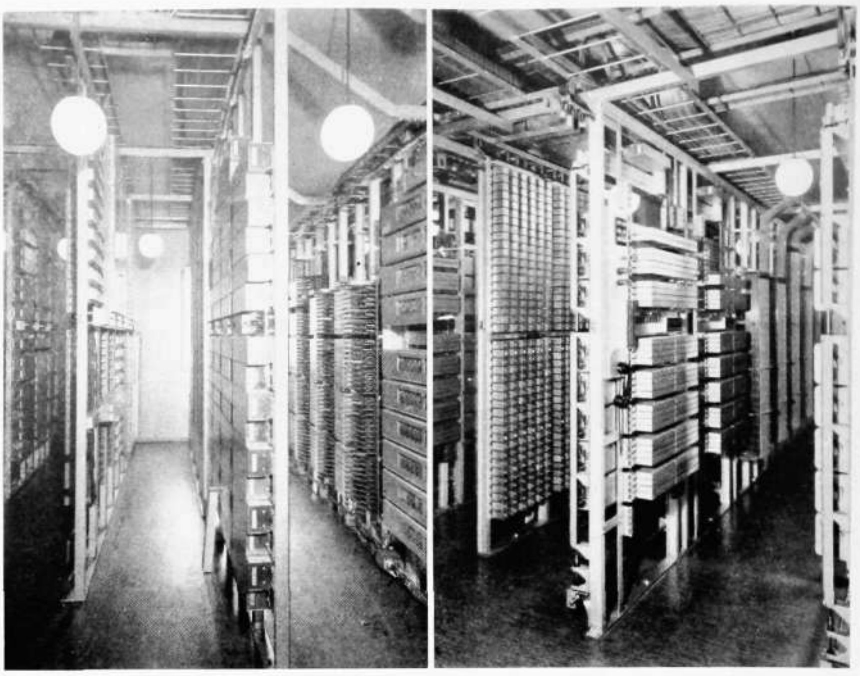


Fig. 4 X 5878

Interior of the apparatus room at Åbo telephone exchange

picture to left: left suite of racks for 1000 numbers; right, connecting circuits with register finders and register for trunk traffic together with repeaters for automatic rural circuits; middle, rear of 1000 line group, left, line relay rack

The Local Exchange

The automatic exchange is built with 500-line selectors and, in conformity with the latest stipulations of the Finnish Board of Posts and Telegraphs for automatic exchanges, is constructed for zone rate metering and for direct connection to automatic rural exchanges with direct driven decimal selectors.

The system has five-figure numbering with a final capacity of 40000 numbers for the Åbo network.

The number series *10000—19999* is allocated to the *10000* line group now in use. For expansion above that or for new exchanges in the local network the number series *20000—29999* and *30000—39999* have been reserved. The rural exchanges in the Åbo district will on automatisation in the future be allotted numbers in the series *80000—89999* and the necessary joint traffic in conjunction with neighbouring telephone districts will be established over the routings *70—79*. These are at present provisionally used as call numbers to neighbouring manual rural switchboards in the Åbo district having automatic junction lines to Åbo.

The routing figure *9* is to be used as call number to the trunk network in the event of reconstruction of same for automatic rapid traffic.

Trunk and toll ordering and other special services are called by numbers from the series *00—09*.

For the establishment of trunk calls to the manual rural subscribers a special routing with call number *61* has been allotted. This routing is only accessible from the trunk exchange.

For the 10000 line group now in use the economy connecting principle has been applied in respect of the group selector multiples. This means that traffic over this group is routed over only one group selector step. When the two 10000 line groups reserved for the local network are brought into use a second group selector will be inserted.

The same applies to the routing reserved for rural traffic, which in addition may eventually comprise still further group selector steps at the main ex-

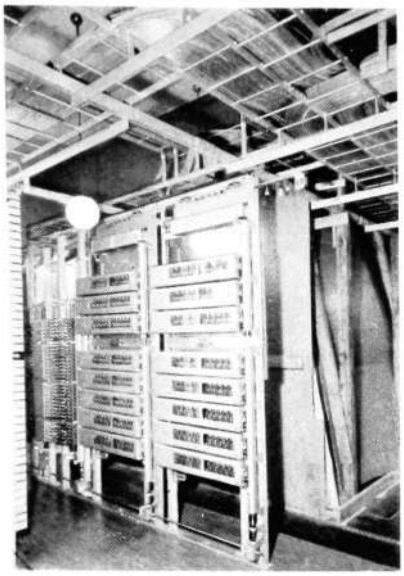


Fig. 5 X 4184

Register panels in the apparatus room

in the background to the right my be seen the screening to the old exchange

change, depending on the size of the rural exchanges to be connected. The second group selector step *GV spec* for this routing is already built and contains, besides the ten routings to nearby rural districts, the ten special routings and the junction route from the trunk exchange to manual rural districts.

Two of the sixteen 500-line groups supplied are arranged for the connection of P. B. X. subscribers. The other fourteen groups are intended for ordinary subscribers only.

The system is provided with mobile polarity reverse, which is actuated when the called subscriber answers or replaces the handset, thus ensuring complete answering and clearing signals to repeaters etc. connected to the system over the line finder multiples. The connection of coinbox automatic instruments of LM Ericsson construction is also made possible by this feature.

Repeated call metering whilst calls are in progress has been provided in simple manner by furnishing the finder multiple with a special metering wire. To allow for rural automatisation and the zone rate debiting associated with it, the system is made for single clearing signal when the called subscriber replaces the handset. This subscriber will then be immediately free of the connection, but the connecting devices are not restored until the calling subscriber too has replaced his handset, this also provides the possibility of localizing malicious calls.

When the calling subscriber replaces the handset a clearing signal is also given right through the system to the called subscriber, so that on traffic over long circuits, *e. g.*, to rural exchanges, these are not held occupied unnecessarily by the called subscriber. By the intervention of the junction line repeater the connection can be disconnected without the called subscriber having replaced the handset.

Besides the above facilities of inter-working with exchanges built with direct-controlled decimal selectors in a closed number series common to the network group, it is possible for automatic switchboards lying outside this numbering to be connected. The system is provided with devices for through impulsing, which furnish this facility. These switchboards are called with open routing figures, which may consist of two-figure special numbers or ordinary subscriber numbers.

The ringing signal in the system is so adapted that party-line subscribers may be connected.

Trunk traffic to the local exchange is routed over a group of 150 junction circuits. These are equipped in the local exchange with connecting circuits and trunk group selectors. The local subscribers are reached direct via the trunk selectors in the respective 500-line groups, and over another group selector step the associated rural exchanges are reached direct and the manual rural exchanges via the rural position at Åbo.

The trunk connecting circuits are equipped with register finders which have access to a common group of trunk registers. These connecting circuits and registers are so made that, in respect of through impulsing, party line ringing and joint traffic with rural exchanges, they give the same facilities as for local traffic. As regards trunk traffic special features mark these junction circuits as they are equipped with devices for breaking in on local connections and breaking them down by means of special action from the trunk positions. On breaking in, the speakers are warned by a special tone, indicating that the operator can overhear the conversation even if she does not immediately announce the trunk call.

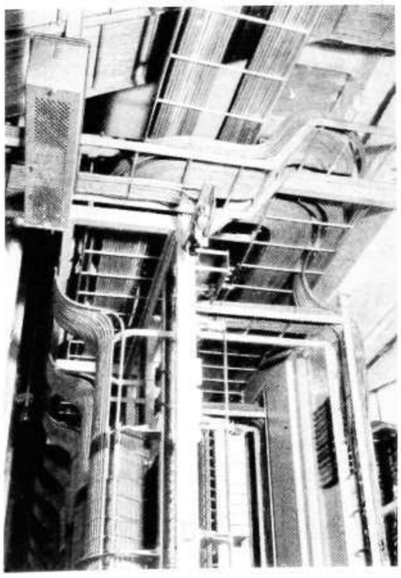


Fig. 6 X 4185

Complicated cable centre in the apparatus

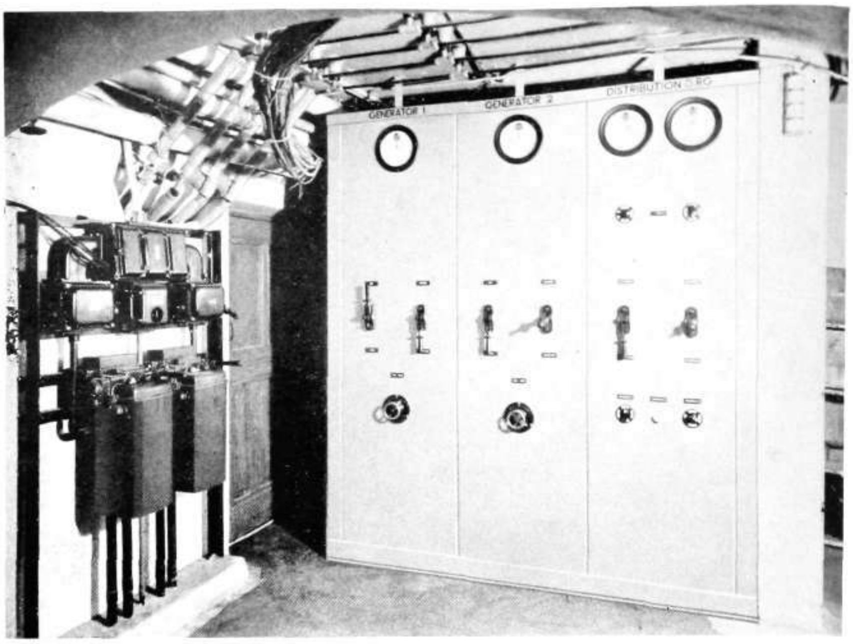


Fig. 7 X 5877

Power plant

left, starting devices for converter, right, charging panel

The ringing of a subscriber who is engaged on a local call is marked for the trunk operator by a special tone, which thus indicates that breaking in is necessary.

Ringing signal is directed entirely from the trunk exchange. By means of visual signals in the trunk position the operator can supervise the connection.

Traffic via Åbo to and from the nearby rural exchanges is established over automatised junction circuits.

Outgoing traffic is distributed over a second group selector step to the different routings which have two-figure numbers. Thus the subscribers themselves select the desired routing. For establishing incoming traffic the junction circuits are connected to ordinary subscriber numbers in the finder multiples. The operator at a rural exchange selects with the dial the number required and has therefore access both to local subscribers and to other nearby rural exchanges, special routings, toll and trunk ordering over these circuits.

To some of these rural exchanges the distances from Åbo are so short that the calls are not subject to any charge beyond that applying for ordinary local calls. Duration of call is not limited.

Impulsing from these exchanges is done with D. C. and the circuits are not equipped with special repeaters.

The longer circuits, for which special call charges are debited, are equipped with repeaters. Debiting is done with special time metering unit which sends the requisite metering impulses to the subscriber's call meter. Either D.C. or A. C. is used for impulsing.

These circuits also have connection to the manual rural exchanges. Calls from these can therefore be established direct to rural districts without making use of the junction circuits. In the same way the rural exchange at Åbo can be called direct from the rural exchanges by special signal.

The multiple of the automatic rural circuits located in the rural exchange at Åbo is also used for dealing with delayed calls to rural centres. In each outgoing direction to these from the automatic exchange, there is a recording circuit terminating at the rural positions. If all circuits in one direction are busy the call then goes to the recording position and the call can be ordered in the rural exchange at Åbo to be dealt with later when a circuit becomes disengaged.

Rural Exchange

The manual rural exchange is built for 90 connecting circuits to the more distant rural centres, 20 junction circuits from trunk exchanges and 60 automatic junction circuits to the local exchange.

Nine operator's positions are arranged for traffic to and from the local exchange and for traffic between the rural centres, and one position is intended for establishing trunk calls to rural districts. The ordinary operator's positions are equipped with pair cords and the junction position with single cords.

Each rural circuit is provided with a relay assembly, which contains devices for receiving and transmitting calling and clearing signals and for call metering. The equipment at the positions is thus made very simple and all signalling to and from the operator's positions is done with D.C.

All rural and ordering lines are reproduced in all operator's positions, thus ensuring the best possible distribution of the work.

The plant was opened on 4th July, 1942, in the presence of representatives of Åbo town authorities, the Finnish Board of Posts and Telegraphs and the contractor. The Åbo Telephone Association on the same day celebrated its 50th anniversary, the memory of the undertaking's farsighted founder, Captain Frans Nordfors, being suitably honoured.

Semi-Automatic Rural Exchanges

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The L M Ericsson semi-automatic rural exchanges are intended to replace small switchboards of L. B. type and combine the operation for a number of small L. B. exchanges to a common operating place. The system compared with a manual L. B. system involves no alteration of the traffic capacity, number of lines or demands on the construction or insulation of the subscriber network. The telephone instruments are normal L. B. magneto instruments and are operated in the ordinary manner.

Since automatic telephone service in cities and large communities has proved its incontestable superiority over both manual and semi-automatic operation, automatisation has progressed more and more in telephony. While suburban traffic, as a result of its dependence on the main centre is going over directly to automatisation, trunk traffic tendency is towards semi-automatic telephone operation on long circuits and automatic working on short sections. In densely populated rural districts automatic traffic has also shown its adaptability and power of competition as compared with manual and semi-automatic operation. It is only in the sparsely populated rural areas with small exchanges at relatively long distances from each other that the manual exchanges have hitherto been unaffected by the revolutionary influence of the automatic telephone.

The telephone was introduced and continues to be introduced in all the more remote corners of the country earlier than electric power distribution. The magneto generator and the dry battery have therefore been telephony's first power source, on which many small switchboard exchanges will for a long time yet come to be dependent. Nevertheless improvements in rural telephone service are sorely needed. It is of particular importance to attain 24 hours' service at all exchanges, which hitherto has not been possible on account of the operation costs being too high.

The installation costs for carrying out complete automatisation are, however, considerable, especially as it is not only the exchange itself that is affected but also the line network. Automatic operation requires an abundance of junction lines and good, well-insulated subscriber lines. Moreover the magneto instruments must be exchanged or converted and provided with dials. The exchanges themselves would likewise, in view of operation, maintenance and power supply, be too complicated for automatic exchanges for 10 to 20 subscribers to displace the present L.B. exchanges. Therefore a solution must be sought for the telephone problems of the sparsely inhabited rural districts by a compromise between manual and automatic operation, *i. e.*, by semi-automatic telephone operation.

The principle of a semi-automatic system is concentration of a number of small manually served exchanges' operation to a place in a central situation. The various switchboards will then be exchanged for automatic exchanges which will transmit the calls from the subscriber lines over junction lines to the nearest exchange with manual attendance. A semi-automatic system may naturally be constructed in a number of different manners. If the same requirements are imposed on small semi-automatic rural exchanges as for fully automatised networks then the conditions for simplification and economy will be greatly diminished. Line material and telephone instruments which are in working order should therefore be left untouched by the automatising. As manual service is retained, all charging and supervising of the calls should be done through the operator. The utilization of the junction circuits at traffic peaks must with semi-automatic operation be made as effective as with manual operation, so that all calls which cannot be immediately dealt with on account of shortage of lines should be registered by automatic waiting or by recording at the operator's position. For calls within an exchange the junction line to the operator's position should be released as in manual operation so that a local call cannot interfere with outgoing traffic.

Semi-automatic systems for rural exchanges must, however, be restricted to small exchanges. Their object, of course, is to bring down operating costs so that 24 hours' service may be ensured at exchanges which in view of their small number of subscribers cannot support the cost of night service or of automatic telephone operation. By having all calls going through an operator, good facility for adaptation to larger automatic or trunk exchanges is obtained, as all telephone plants must be capable of cooperating with a manual operator's position for magneto instruments. The semi-automatic position will advantageously be combined with other operation, *e. g.*, for direct L.B. subscribers, coin-box instruments, rural lines or trunk lines. Such facilities of combination will often be decisive factors in the financing of a semi-automatic exchange. The relay devices for the connection of junction lines must therefore be adapted for each case to the existing exchange of the main centre, without affecting the semi-automatic exchanges.

Telephone secrecy is better ensured in a semi-automatic network than in a manual one, both because the internal calls are entirely secret except for party-line subscribers, and because the number of operators who may overhear is reduced while the interest for unauthorised listening is less when the operation is centralized to a main centre. Party lines with code signalling may be connected as is the case with manual exchanges and likewise one or two coin-box instruments per exchange.

Semi-Automatic Rural Exchanges

The design of LM Ericsson's semi-automatic rural exchanges is such that they can directly replace a manual exchange for magneto instruments having L.B.-feed. For the subscribers the substitution involves no change beyond the necessity of informing them of the significance of automatic waiting indication, consisting of a ticking tone which announces that the operator's position cannot be reached as all junction lines are busy, but that the subscriber will be called as soon as the call can be dealt with. The exchanges are for indoor mounting but well enclosed and furnished with locks so that they may be located either at the place formerly occupied by the manual switchboard or in a hall or office room. The required input of electrical energy is exceedingly small and is met by dry cells or storage batteries. Generally, during conversation no current at all is taken from the battery. During the connecting and the restoring processes current impulses are required amounting to from 0.5 to 1 A, but they are of very short duration. Consequently the current consumption amounts to only a few ampere-hours per year and the size of the battery is governed solely by the discharge current required. Neither batteries nor protector strips are enclosed in the automatic exchange but are mounted separately. The battery voltage is 24 V.

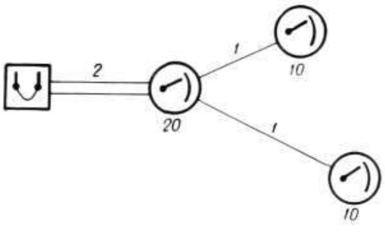

Fig. 1 X 3994
Principle diagram of semi-automatic system

◫ manual operation
◷ 20-line junction exchange
◷ 10-line terminal exchange

The LM Ericsson system is based on three sizes of switchboard, a 10-line terminal exchange switchboard, a 20-line junction exchange switchboard and a 40/60-line junction exchange switchboard. Two junction exchanges may be connected in series and the furthest be furnished with terminal exchange equipment as well. Not more than three series-connected junction circuits in addition to the subscriber line itself should be allowed between the subscriber and the operator's position, as the operator's supervision over waiting times

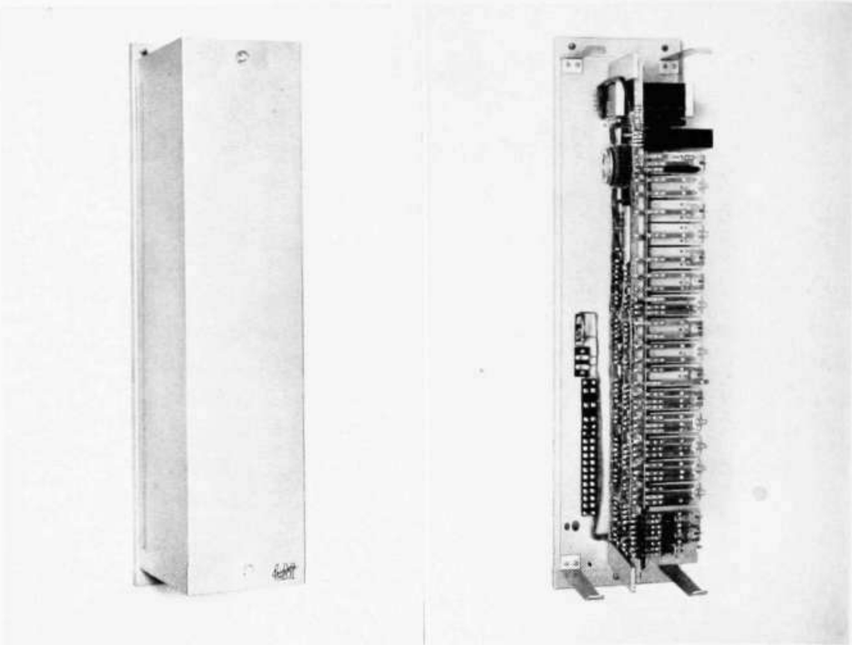

Fig. 2
Semi-automatic exchange for 10 lines

and internal connections would be too poor for the farthest exchanges. The terminal exchanges are provided with only one junction circuit to the next superior exchange. Over this junction circuit all switchings to and from the subscribers and between them are routed. 20-line junction exchanges may be furnished with two junction circuits to superior exchanges and may permit of the connection of two sub-exchanges, usually 10-line terminal exchanges, see Fig. 1. A 60-line junction exchange may be equipped with up to 5 junction circuits to the manual exchange and four junction circuits to sub-exchanges.

The terminal exchanges are available in two forms, either party exchanges with the junction circuits occupied during internal call or as semi-automatic terminal exchanges possessing facility for internal call, which allows of outgoing or incoming call proceeding at the same time as an internal call. A 20-line junction exchange switchboard is equipped with not more than two and a 60-line switchboard with not more than three internal call facilities, which do not occupy any of the junction circuits during conversation. The exchanges for 10 lines, Fig. 2, are intended for wall mounting and take up a wall-space of 200 × 700 mm for party exchanges and 200 × 860 for semi-automatic switchboards. The two larger types of switchboard are set up on the floor and the 20-line switchboard, Fig. 3, takes up a floor-space of 535 × 450 mm, while the 60-line switchboard requires a space of 1020 × 500 mm.

Operation and Supervision

The operating procedure with local traffic conforms as concerns the subscribers entirely with that customary for manual L.B. exchanges. The subscriber calls by cranking his generator which causes a line relay at the semi-automatic exchange to be energized and held. If there is an unoccupied junction line from the exchange the subscriber line is hunted by a selector and at the same time the call is automatically repeated to the next superior exchange. At the operator's position a call indicator drops or a call lamp lights up. The subscriber gives the number of the subscriber he wishes to speak with and the operator establishes a connection between the two subscribers by means of the dial. The operator sends out ringing signal and can then disconnect herself from the connection. If the called subscriber is busy an impulse is sent back to the operator's position causing an indicator to drop or a lamp to light. The operator announces to the calling subscriber that the line is busy.

Calls, whether passing through or remaining in the exchange where operation is attended to, come under the direct supervision of the operator on duty and are disconnected by her, when the subscribers ring off or the operator finds that the conversation is terminated. Calls within or between the semi-automatic rural exchanges are cleared automatically when the subscribers ring off, but in addition they are under a special indirect supervision which prevents connections which have been left without clearing from blocking the connecting devices and the junction circuits. For calls within an exchange this supervision consists of the operator receiving busy signal after the dialling of the first digit in the next connection which for its completion is dependent on the busy instrument. The busy signal, as stated above, is visible, *i. e.*, consists of an indicator dropping or a lamp lighting at the operator's position, so that there is no difficulty in deciding whether a busy signal arrived before or after the last digit in the subscriber number.

A forgotten internal connection cannot block the traffic. The subscribers who have omitted to give clearing signal are of course marked busy, but they are not blocked. On call the forgotten connection is liberated and the operator can always cut in on busy-marked subscriber lines to offer a waiting call. An internal call can always be broken by a ringing signal. As a neglected connection prevents the establishment of another internal call, it is incumbent on the operator to check whether conversation is proceeding or not over the internal connecting devices. This is done by ringing a special number, which gives her speech connection with the respective connecting circuits. If conversation is proceeding she can hasten it; if no conversation is proceeding she will break the connection by a ringing signal. This ringing signal does not go through to the subscribers. In order not to leave out a subscriber number, special digits containing 11 impulses have been introduced to reach the internal connecting circuits. In a 10-line semi-automatic terminal exchange *10* or *20* is dialled but by means of a press-button a short-circuiting for an extra impulse is opened when the digit *0* is dialled. In a 20-line junction exchange *30* or *40* is dialled, enabling the operator to come in on one or the other of the two internal connecting circuits. The corresponding numbers for the 60-line switchboard are 40, 60 and 80. With the old model LM Ericsson dials it is possible to obtain 11 impulses by taking the dial beyond the stop.

For connections established over junction circuits in a semi-automatic network group, there is started a timing device immediately the operator completes the connection. If clearing has not taken place before the close of a

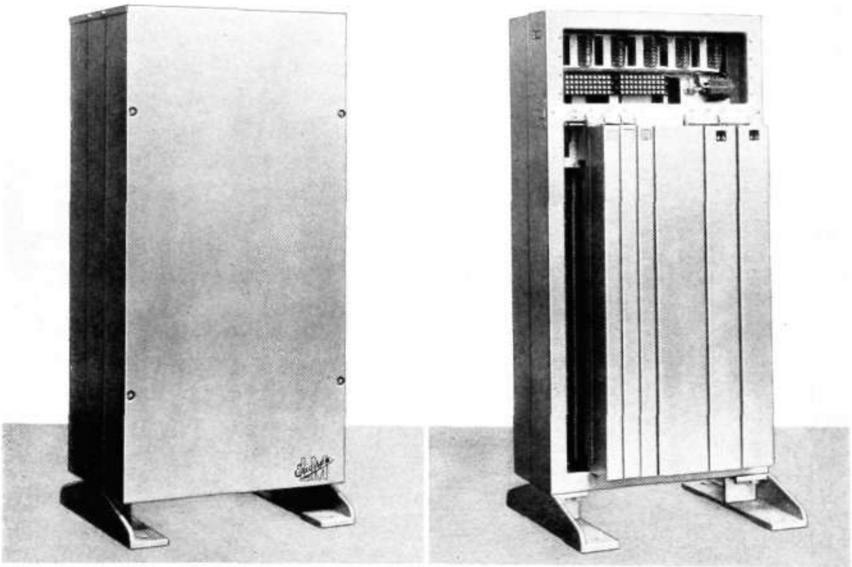

Fig. 3
Semi-automatic exchange for 20 lines

unit call period, the circuit is automatically reconnected to the operator in the form of a call. If conversation is proceeding the operator may allow it to continue for a further period or disconnect the call by a ringing signal. If conversation is not proceeding the operator cannot always definitely decide whether the call came from a subscriber on the waiting list or from a connecting circuit time device, so she must always send out a ringing signal and await reply. If no answer comes then the answering cord is taken down. The ringing signal has, however, released the neglected connection. When the operator tries to connect over a busy junction circuit she receives busy signal, but she can connect herself in on the circuit by a ringing signal and then, if necessary, release the circuit by a further ringing signal. By means of the indirect supervision the introduction of automatic time restriction is avoided and the operator has to decide whether a prolonged conversation is to be broken or not.

Automatic Waiting and Fault Signalling

All calls from subscribers who cannot come through to the operating position are automatically put on waiting. A ticking tone is then emitted from the subscriber's line relay or the line relay of the junction circuit, which on account of lack of connecting device stays in calling position. When the subscriber hears the tone he knows that the call has been received at the telephone exchange but that it cannot be handled without delay. He may then replace the handset and await ringing signal from the operator. If the subscriber receives neither ticking nor answer from the operator, he should send another calling signal. It may, indeed, be that an earlier connection has been left without clearing signal, in which case the first calling signal has been taken by the exchange as a clearing signal. Disconnection after clearing is delayed to prevent one of the two clearing signals, received when the two subscribers ring off at the close of a conversation, from producing a new call.

The ticking tone indicating waiting to the subscribers is also employed for signals to the operator. In calling to a semi-automatic exchange it is used as exchange tone and shows that the battery voltage at the exchange is sufficient. If this answering signal does not come when the operator inserts the ringing plug or connects herself in by dialling to an exchange not directly connected, it means that the dry batteries are beginning to become exhausted. In spite of this the exchange will still operate for a long time but when occasion arises a fresh cell should be put in or the battery exchanged if it is used up.

The ticking is also employed to designate calls from coin-box instruments. The tone then continues when the operator answers the call and she must break the tone with a ringing signal before obtaining speech connection with the coin-box instrument.

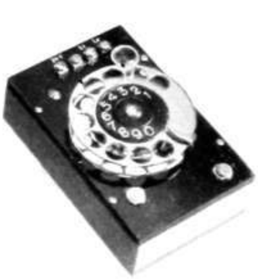
Fig. 4
Test box for semi-automatic exchanges

Frequently calls routed over junction circuits are subject to special charges. In order that the calling subscriber's number may be checked if required, the conversation must be noted by the operator. This procedure is also advisable with much waiting so that the calls may be given the order of their coming in. It has therefore been necessary in a semi-automatic network that the operator may be in a position to connect any two subscribers in the network, without either of them being the caller. The operator then first dials the wanted subscriber's number, sends ringing signal to the subscriber, awaits answer and then dials the subscriber number given by the person ordering and rings that. When the conversation begins and the operator leaves the connection the automatic timing device starts up on junctions not directly supervised and this after a period connects the call to the operator.

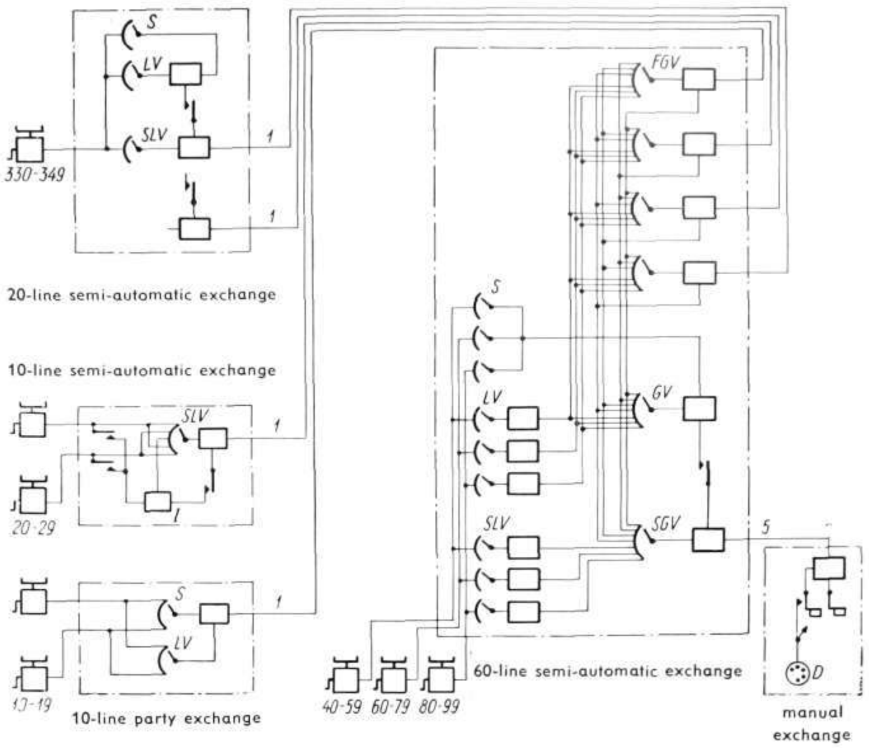

Fig. 5 X 6093

Diagram of semi-automatic exchange

D	dial
FGV	line selector
GV	group selector
I	internal call circuit
LV	line selector
S	line finder
SGV	combined line finder and group selector
SLV	combined line finder and line selector

Alarm signal is given by a semi-automatic exchange if a fuse goes or if a selector is not restored after a clearing signal. The alarm signal consists of a prolonged calling signal which actuates a special signal indicator or lamp. At the same time the junction circuit or circuits affected by the fault are connected to a certain instrument through which connection with the operator can be maintained.

To make it possible to test all the functioning of a semi-automatic exchange at the place of installation without the aid of the devices, *e. g.*, dial at the manual exchange from which operation is handled, there is a test box, Fig. 4, specially designed for the purpose. The box, the main components of which are dial, two press switches and a visual indicator, is connected along with a magneto instrument, *e. g.*, a portable telephone instrument, by means of two wires to the line terminals of a junction circuit and by two wires to the battery terminals of the exchange.

Circuit Diagram

The circuit diagram of the semi-automatic exchanges may be seen from Fig. 5. The terminal exchanges each contain only one rotating selector *SLV*, which hunts the calling subscriber on call from the exchange or is directed to the wanted subscriber line on call to the exchange. On internal calls the subscriber lines are switched by individual relays to a speaking circuit *I* which contains devices for disconnecting on clearing. Party exchanges contain two selectors, one of them *S* functioning as finder for outgoing call and the other *LV* as final selector for incoming and internal calls.

In the 20-line switchboards the subscriber lines are connected to the multiple for the selectors *SLV* on the two junction circuits to the junction exchange switchboard and to the selectors *S* and *LV* for the terminal exchange's internal connecting circuits. The selectors *SLV* in the 20-line switchboard have the same purpose as the selectors *SLV* in the 10-line semi-automatic switchboards. The two internal connecting circuits can be connected to either of the line equipments and are connected immediately an internal connection is started by means of relays, which latter are separated and release the junction circuit when the operator disconnects the call.

This switchboard may also be used as junction exchange switchboard, in which case the junction circuits from terminal exchanges are connected to separate final selectors, over which calls are established to the terminal exchange subscribers or calls between sub-exchanges.

The 60-line semi-automatic switchboard in the junction exchange differs in respect of diagram from the 20-line switchboard chiefly by the introduction of a group-selector step. The subscribers therefore are connected to the multiple for the selectors *SLV*, *LV* and *S* and the sub-exchanges to the selectors *FGV*. These last together with the selectors *SLV* are connected to the multiple for the selectors *SGV* on the junction circuits to the manual exchange. The selectors *LV* and *S* are comprised along with *GV* in the internal circuits of the junction exchange. The selectors *SLV* have the same function as the selectors *SLV* in the 10-line switchboards. The selectors *SGV* hunt *SLV* or *FGV* on call to the manual exchange. On call from the manual exchange to subscribers in the junction exchange or sub-exchange a selector *SGV* is set to a selector *SLV* or a junction circuit. The selectors *FGV* are set out by impulses from the manual exchange when establishing a call from a subscriber in a sub-exchange to a subscriber in a junction exchange or in another sub-exchange.

At the manual exchange the devices for the semi-automatic junction circuits of the switchboards may vary according to circumstances. Usually connection is most simply made by an extra jack alongside the operator's jack, with separate make contact for connecting the dial of the operator's position to the junction circuit. An operating cord, any one of those in the position, is inserted in the extra jack during impulsing. Generally the extra jack and the dial require to be arranged at one only of the manual exchange concentration positions over which all semi-automatic rural traffic, both trunk and local, is routed.

Coin Boxes in Telephone Service

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With the introduction of coin box instruments into a telephone area, the technicians concerned are frequently faced with problems and questions that to some extent are outside those normally encountered in tele-technics proper, and which, in addition to technical conditions, also involve psychological features. The varying circumstances regarding coinage and rates in different countries combined with the dissimilar technical conditions at various places call for individual adaptation to local conditions for each separate locality.

The object of the present article is to indicate in the light of historical developments the possibilities and limitations existing at the present time in this sphere. Further, some new fields of employment for these instruments are described, the consideration of which should no doubt contribute to the popularization of the telephone, which is more or less of vital interest to every telephone administration.

At quite an early stage in the development of telephone practice the idea of introducing public telephones in the telephone networks appears to have found application. In an account of telephone activity in Stockholm, for example, it is found, that as early as 1883 public telephones were available, whereby the public could, for a certain charge, converse with subscribers to the network. As far as can be judged these were ordinary telephone instruments; payment of the charge was supervised locally. In an American patent of 1889, *E Gray* put forward the idea of fitting the telephone instrument in a cabinet, which could only be opened after insertion of a coin. This design in all its primitiveness may well be regarded as the forerunner of our present-day coin-box instruments. L M Ericsson's first coin-boxes were introduced about 1895 and were arranged for audible signalling of the payment by means of a bell, the tone of which was transmitted to the operator by a fixed microphone on the instrument. The subsequent introduction of the handset led to the electrical signalling of the payment. This was carried out by different designers on varying principles, either by the coin closing a circuit during its passage through the coin-chute or by the coin causing a spring to vibrate in order to produce a buzzer signal.

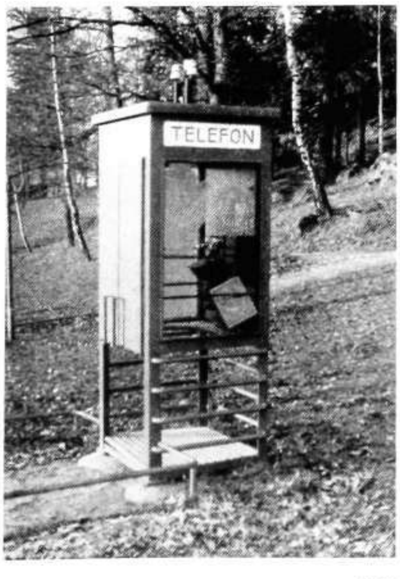

Fig. 1 X 3990
Telephone kiosk of the Swedish Telegraph Administration design

Technical Considerations

The first coin box instruments were made for post-payment, i. e. payment was made at the request of the operator, after the connection had been made and the called subscriber had answered. It was soon recognized, however, that this method of operation was time-consuming and expensive, since the operator had to await the payment of the charge before the instruments could be connected. For local traffic with fixed charge particularly the service can be much more rapid, if the coin is deposited on requesting the call and requires only to be encashed on establishment of the connection. If the required subscriber is busy or does not answer, the deposited amount must be refunded.

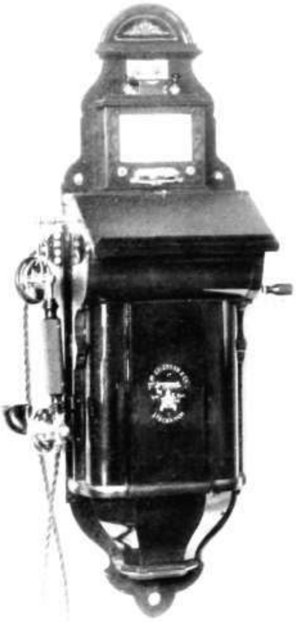

Fig. 2 X 3973

Coin box instrument AB 6500 for magneto system (1900)

encashment and refund are accomplished by pressing the button at the side of the coin-slot; encashment of the amount is signalled to the operator by a vibration contact

Various designs on this prepayment principle appeared around 1920. In carrying out the designs it seemed at first more convenient to let the operator deal with encashing and refunding respectively. These operations, however, required special equipment at the exchange in the form of encashment and refunding keys, which operated a relay in the coin box and effected the encashment or the refunding of the amount deposited.

The inconvenience caused by the introduction of these special devices, particularly in older exchanges, combined with the desire to relieve the operator of special attention to calls from coin box instruments, soon gave rise to other solutions, where the manipulations for encashment and refunding were left to the calling party. The coin box instruments were furnished with encashment and refund buttons, the former to be depressed when the called subscriber answered, whereupon the money was encashed and the connection established, and the latter to be used if no answer was received and the money was required to be refunded. This, however complicated the use of the instrument. The next stage of development therefore was to eliminate these buttons. The problem was to utilize in each individual case the special properties of the switching system used at the exchange or to supplement it in such a manner, that the requisite impulses to the instrument were obtained automatically on completion of the establishment of the call.

In manual systems, where the impulse for call metering is obtained at the commencement of the call, i. e. at the moment when the called subscriber answers, this impulse can as a rule be utilized for automatic encashment of the coin. In this case a special relay in the connecting circuit at the exchange produces current reversing on the calling line. A polarized relay in the coin-box instrument encashes the coin and the encashment button may be dispensed with. If local calls only are allowed from such instruments, the operator can deal with these calls in the same manner as calls from normal instruments. However, to be accomplished in a simple manner this method requires that the microphone current should be fed from the connecting circuit during conversation. In systems where the above impulse on answer from the called subscriber cannot be provided the encashment button is indispensable. Nevertheless in most cases it is possible to arrange refund automatically through the handset hook when the handset is replaced.

The ever-increasing automatisation of telephone exchanges created an early demand for coin box instruments adapted for connection to such exchanges. Of course, as a rule, it was possible during the period of automatisation to confine the serving of coin box instruments to the remaining manually operated exchanges, but this facility decreased progressively as the conversion to automatic working proceeded.

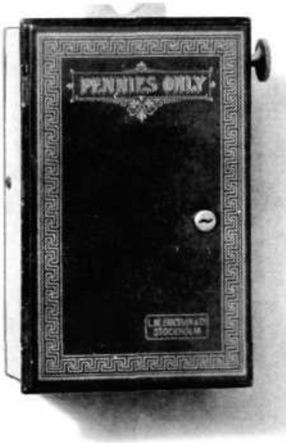

Fig. 3 X 3974

Coin box AB 6000 for L. B. and C. B. systems (1902)

The coin is encashed when the knob to the right is given a half turn, the coin being then recorded in by a counter mechanism in the instrument, encashment signal being sent at the same time to the operator by a buzzer

The first coin box instruments for automatic systems were designed only for local calls and were fitted with press-buttons for manual encashment of the charge. The refund in some designs was manual with the use of special refunding buttons, and in others it was automatic, working from the hook. In those automatic systems, however, where the call metering takes place at the beginning of the conversation, the metering impulse can be employed for current reversing on the line and automatic encashment. Later designs intended also for trunk and zone calls have been produced, with provision for facility of free calls to ordering operators, fire brigade, ambulance etc. These instruments, however, are fairly complicated, both in design and operation, in addition to requiring special equipment at the exchange.

It is easily comprehensible that in a coin box instrument, with a special refunding device, the internal mechanism will be complicated if complete security against defect or failure in refunding is to be attained. The instrument should only encash on effective calls and should not be prone to frandulent

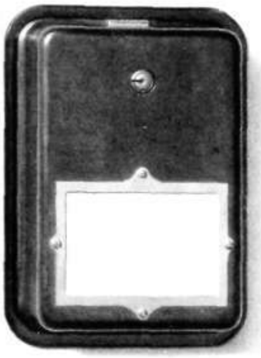

Fig. 4 X 3975
Coin box AB 6200 for L. B. and C. B. systems
with vibration contact

manipulation. The adjustment and maintenance of the instrument will therefore often be a troublesome and expensive matter and the purchase price too will increase in proportion to the complicated construction of the instrument.

An appreciable simplification of the whole instrument, however, was made possible by the introduction of open depositing of the charge. This means that the amount in deposit is accessible to the person telephoning and may be taken back without special manipulation in case there is no answer. This disposes of the whole problem of refunding device, and the construction of the coin-box instrument may be simplified to a high degree. In cases where the automatic encashing impulse is obtained by current reversing on answer from the called subscriber, no button is required on the instrument and its use therefore will be the simplest imaginable. Calls without charge to fire brigade, ambulance etc. may be easily arranged by suppression of the current reversing. It should be observed that in this case no coin is needed for making the call, as is usually necessary with refunding instruments, where even for free calls the amount must be paid in first, then refunded on completion of the call.

One result of dispensing with refunding device is that coins of lower values and smaller size than the instrument is intended for are not refunded either, but proceed direct to the coin box without producing conversation. Since, however, most of such payments are made with dishonest intention, this might rather be considered an advantage, as the loss of the coin will tend effectively to discourage further experiment.

Economic Considerations

The direct economic yield from the call office service may naturally be computed in given cases, where particulars of the cost of plant and maintenance together with the income earned are available. An investigation of this matter, respecting conditions in Berlin, has been dealt with in detail by *H Pressler*, and from this the particulars which follow are derived. The annual costs per instrument for the various types of coin-box instruments in use are made up as follows.

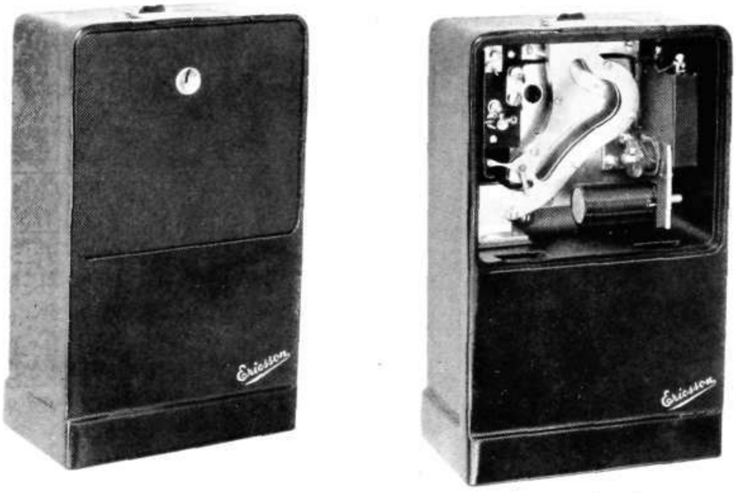

Fig. 5 X 5621
Coin box for L. B. and C. B. systems
in thief-proof construction; encashments of the coin is signalled by a vibration contact actuated by a bell crank lever in the coin-chute

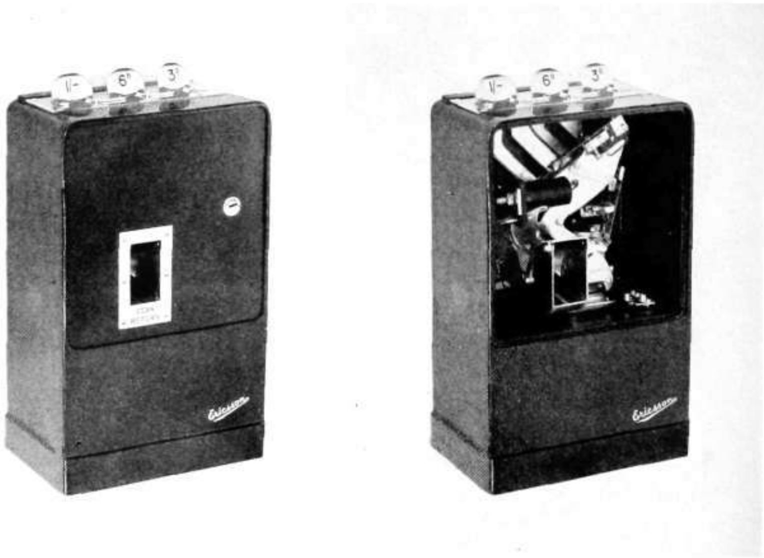

Fig. 6 X 5622

Three-denomination coin box for L. B. and C. B. systems

with refund chute for incorrect coins; the value of the coin is signalled by vibration contacts actuated by bell crank levers in the coin-chutes

Coin box instruments installed for	Capital cost RM	Maintenance cost RM	Total annual cost RM
Private subscribers	112	200	312
Public buildings	147	300	447
Streets	159	300	459

The distribution of calls and earnings for different groups of public coin-box instruments have been reckoned on the basis of statistics of December 1931, with the assumption that 11.8 % of the annual traffic occurs during that month.

Public coin box instruments installed for	Instruments	Calls		Annual income per instrument RM	Profit in % of annual cost
		Total	Per instrument		
Private subscribers	2155	1108193	515	437:75	40
Telephone exchanges	941	1180021	1254	1065:90	138
Public building	432	275764	639	541:40	21
Streets and squares	450	1002676	2228	1893:80	312
Railway stations (outside the barriers)	297	536472	1806	1535:10	234
Railway stations (inside the barriers)	51	65933	1293	1099:05	139

The figures in the last column show that the yield on capital engaged is largest for the instruments placed in street kiosks and available day and night. However, even the group with the smallest yield — coin box instruments in public buildings — give a profit which must be regarded as satisfactory. The average yield for all the instruments, taking into account the numbers in each group, amounts to 115 %.

If from these figures the total profit for each group is computed, a distribution can be obtained showing the contribution of each group to the total yield. This computation has been put into the following table.

Public coin box instruments installed for	Total profit RM	Distribution of profit %
Private subscribers	270991	14.6
Telephone exchanges	582387	31.3
Public buildings	40996	2.2
Streets and squares	645660	34.6
Railway stations (outside barriers)	319601	17.1
Railway stations (inside barriers)	32642	1.8
Total	1859632	100.0

From this it may be seen that of the total profits slightly more than a third is encashed through instruments in street kiosks. It is noteworthy that the coin box instruments at private subscribers, despite the relatively low yield in comparison with the preceding group, contributed almost 15 % of the total profits. The figures given here refer to conditions in a large city and cannot be applied without modification to smaller places, but failing a more exact basis, it may be estimated that the distribution in per cent would also be the same order of magnitude for smaller towns.

Development Considerations

In judging the significance of the coin box instruments in telephone operation, one should not restrict oneself to economic calculations alone. The indirect importance of these telephones, putting this means of communication at the disposal of all and on all occasions, is certainly in many cases of still greater value than the direct economic yield. Taking the long view, therefore, it is in most cases justified to extend and supplement the call office service, even if the direct economic calculations in themselves do not encourage it. Apart from the fact, that the normal subscription's value is augmented, when it is possible to reach the subscriber not only for other subscribers but also for any other person, the call office service constitutes a promotion factor that should not be under-estimated. People are made familiar with the use of the telephone, thus increasing their disposition to become subscribers themselves. The objection that might possibly be made against this claim, that convenient access to public telephones may make subscribing superfluous for certain persons, does not hold good. Private subscription offers, in all circumstances, such great advantages and convenience, that competition is hardly conceivable.

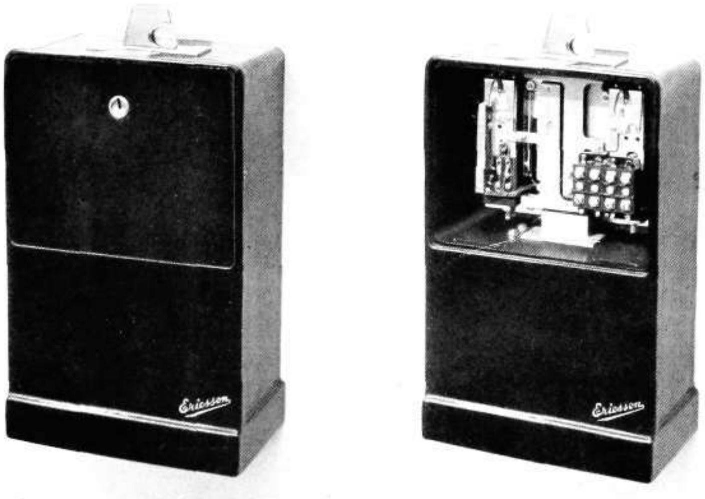

Fig. 7 X 5623
DMA 20 for automatic systems with current reverse on answer
with open depositing and automatic encashment of the coin when the called subscriber answers

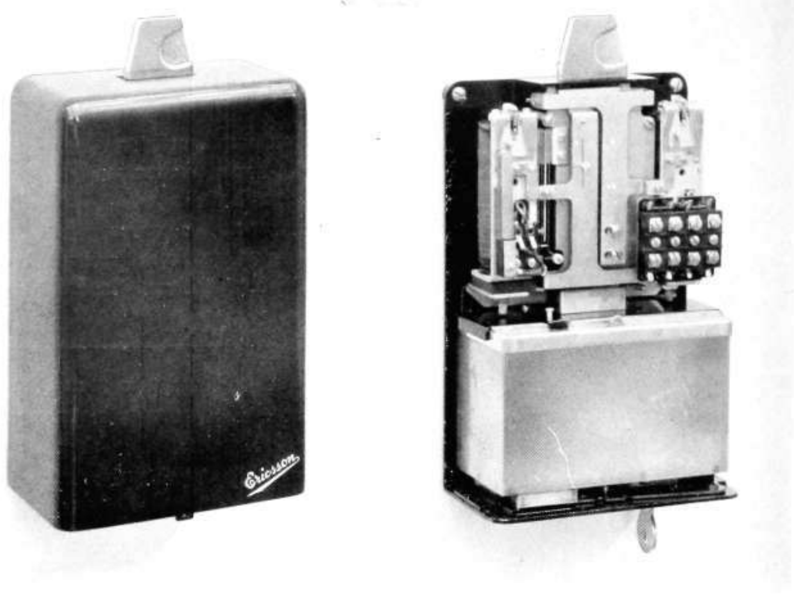

Fig. 8 X 5624

Automatic coin box DMA 30 for automatic systems

intended as home instrument; if the subscriber himself is to empty the instrument the coin container is replaced by a funnel, the coins then are taken out of the instrument through a shutter with lock underneath the instrument

If then the public call office can appreciably contribute to the increase in the number of subscribers in the network, it is still more the case with another form of call office service, *viz.* the private call office. This form of telephone subscription is intended specially for those subscribers, who consider they have little need for outgoing calls, but still wish to have the facility of receiving calls from other subscribers, or who instead of paying the charges at intervals in comparatively large amounts, prefer to pay as and when the service is utilized, as in the case of gas and electricity slot-meters. The subscription is based on a relatively low fixed charge and a correspondingly higher floating charge for outgoing calls, this charge being encashed by the coin box instrument. This form of tariff gives the subscriber the facility of individual adjustment of the costs and thereby — maybe frequently more for psychological than real reasons — appears more attractive than a fixed charge alone. In view of the technical costs a minimum limit for the floating charge is in certain cases justifiable; nevertheless, this in no way changes the floating character of the tariff and is therefore only of minor importance.

It is fairly obvious that a coin-box instrument for this purpose must be cheap in first cost and maintenance, if the total costs are to be covered by the charges coming in, without these becoming prohibitive. The instruments, moreover, should be capable of connection without difficulty to normal telephones thus facilitating appreciably in technical respect a later change-over to fixed subscription. On the other hand, the need for strong construction and security against theft is smaller, since the subscriber in such cases bears the responsibility for any tampering. Another requirement is that the manipulation of the instrument shall be the simplest possible. This, however, is governed to some extent by the construction of the exchange and its functioning, and also by the principle of payment. The open deposit referred to above, with automatic encashment at the start of the conversation offers the greatest advantage in this case, both from the technical point of view (simple design) and in use. Neverheless its utility is restricted to systems where an encashment impulse (through current reversing) is obtained at the start of the conversation.

A special form of subscription for call offices should be mentioned in this connection, the semi-public. It is characterized by a main fixed charge, which is higher than that in force for ordinary subscribers. Unlike the most current form of call office subscription, where the administration collects the charges, the coin box is emptied by the subscriber and the monies taken are his property. This form of subscription is specially suited to tobacconist shops, newspaper stalls, small hotels and boarding houses etc., where free access to the telephone involves the proprietor in far too much expense, while on the other hand direct demand for the telephone charge by the owner presents difficulties and in many cases is psychologically less advisable. Though this form of subscription is by no means new, it deserves mention here, since in many cases it offers an effective solution of the subscriber's troubles. In cases where it has been applied the amount of employment it has gained shows that it satisfies a real need.

Another form of call office telephone service, which has become current with the great increase of traffic on main roads in recent years, is the high road telephone. It was introduced, as far as is known, for the first time in France and has grown considerably in extent. Its primary object is to give motorists in case of accident the facility of rapidly calling help and in this capacity it represents a feature of public safety service on the main roads. In sparsely inhabited regions especially it fulfils a real purpose and its introduction on the dangerous French alpine roads is characteristic in this respect. In cases where the telephones are located in villages and communities along the highways they can of course be utilized by the inhabitants and contribute to maintaining communications with scattered villages which hitherto have been wholly or partially isolated from the outer world.

New Coin Boxes

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Rational manufacture demands uniformity in production and the making of large quantities in series. These demands could hitherto only be satisfied to a limited extent in the manufacture of coin box instruments owing to the variation of coins in the different countries. In the design of L M Ericsson's coin box instrument for automatic encashment, described in Ericsson Review No. 2/1937, the aim was to achieve as far as possible a universal design for use with varying sizes of coins. In the new coin box instrument for manually operated exchanges, described below, this principle has been perfected and the result has been a coin box instrument in which only one feature the coin slot, requires individual manufacture for each kind of coin.

Prepayment coin box instruments of various designs have long been available for manually operated telephone exchanges. As these instruments however cannot be used when the exchanges are changed to automatic service, the telephone administrations have in recent years shown a certain hesitation in acquiring such instruments. Consequently the work of development in respect of coin box instruments has of late years been chiefly confined to instruments intended for connection to automatic systems. Nevertheless, the continued existence of a large demand for public call instruments for manual systems is in ample evidence immediately one gets away from the densely populated urban districts. When one considers, moreover, that manual exchanges still serve almost half of the world's telephone instruments, it can well be realized that a very large market will be found for many years for coin box instruments designed for such exchanges.

The shortage of material due to the world war now terminated has in many places necessitated measures for temporarily restricting increase in subscribers to telephone networks, especially in those networks and exchanges where the available reserve capacity is already limited. In order to be able to some extent to satisfy the increased need for telephoning, despite these circumstances, increase in the number of public call instruments may be considered. In that case, however, it is desirable that the coin box instruments, in the event of future automatisation of the exchange, can be modified without any great expense to work in conjunction with the new exchange.

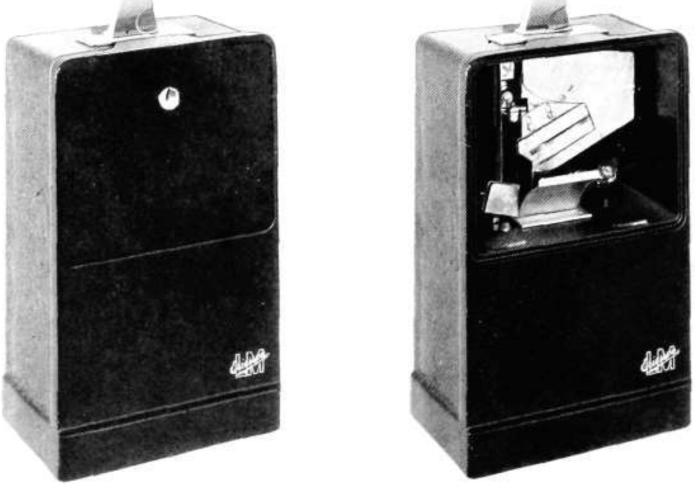

Fig. 1 X 5988
Coin box type DMA 80
burglar-proof; left, with and, right, without case

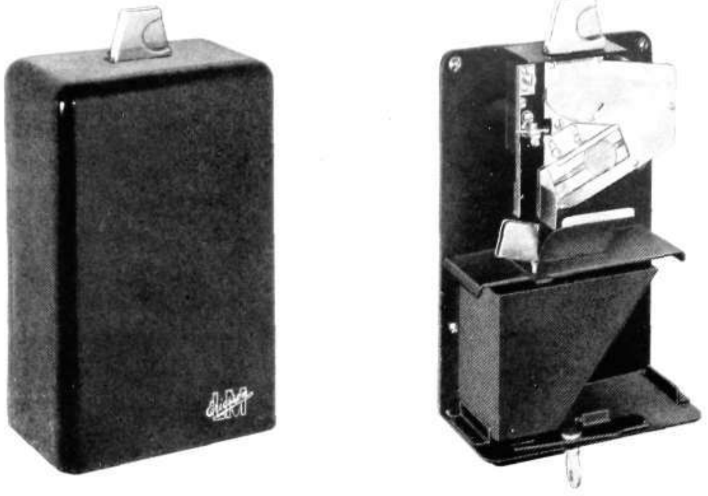

Fig. 2 X 5969

Coin box type DMA 90

not burglar-proof; left, with and, right, without case

Side by side with the development of coin box instruments designed for automatic systems, LM Ericsson has therefore now designed an instrument intended for connection to manual L.B. and C.B. exchanges, with a view to producing an instrument which, when the exchange is automatised, can be adapted for automatic encashment of the charge. At the same time consideration has been given to the form of subscription with coinbox instrument, so popular in many quarters. Such subscriptions require a relatively inexpensive coin box instrument, which however need not be so secure against theft as the public call office and kiosk instruments, as it is usually set up in a place with somebody in attendance. This instrument, therefore, like the coin box instruments for automatic systems, is made in two executions, a burglar-proof type intended for public call offices and a simpler type for coin box instrument subscribers. In designing this instrument a simple and inexpensive construction has been aimed at and the coin box is therefore made as an auxiliary to a normal telephone instrument. The new instrument is constructed with coin chute and coin contact assembled together into an inset which can easily and cheaply be exchanged for an inset for automatic encashment on automatisation of the exchange.

Construction

The burglar-proof instrument, Fig. 1, is fitted in a cabinet of malleable castiron comprising two compartments, the upper for the coin inset and the lower for the cash box. The compartments have separate locks, that of the coin box compartment being a strong patent lock with double bolts. Locks and apertures are countersunk in the case thus giving no purchase for burglar's tools. The coin slot is made as a coin gauge which checks the maximum diameter and thickness of the coin and prevents the insertion of coins larger than those valid. The not burglar-proof instrument, Fig. 2, is made with case and bottom of pressed sheet metal. The case is locked on to the baseplate by a lock underneath the instrument.

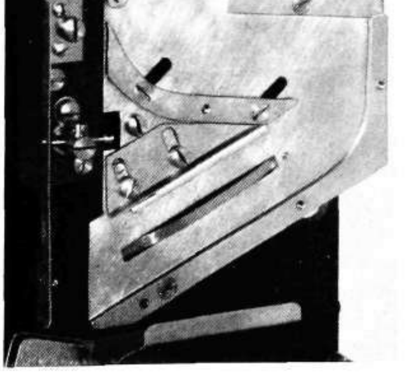

Fig. 3 X 4280

Coin inset

left, coin contact, right, coin chute with adjustable guides

In view of the desirability of low price it has been considered that refunding of incorrect coins can be dispensed with in these instruments. The insertion of such coins is frequently done with fraudulent intent and should not be encouraged.

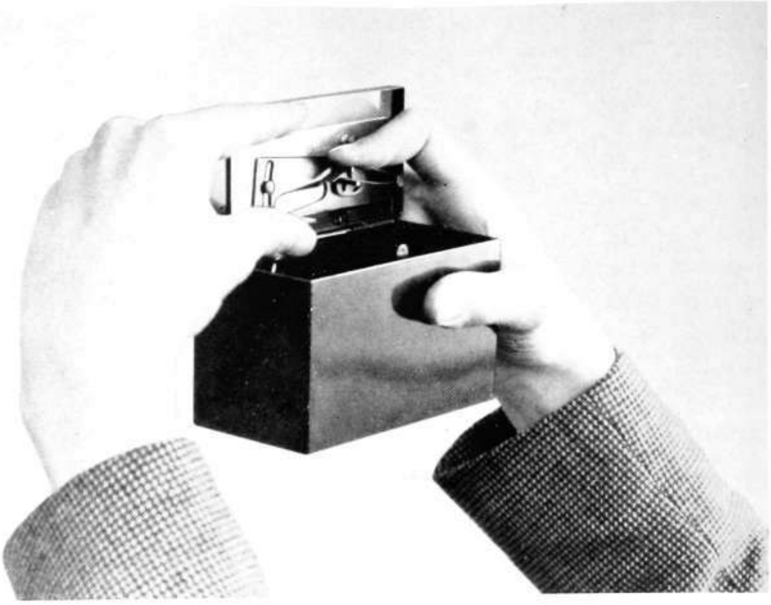

Fig. 4 X 5993

Cash box with locking device

The illustration shows how the locking device is set before the cash box is replaced after emptying

The coin inset, Fig. 3, is the same in both types of instrument and consists of a coin chute and a coin contact actuated by the coin as it leaves the coin chute. The object of the coin chute is to conduct the coin through the instrument in such a manner that on striking the coin contact it has the greatest possible force of movement. The track must be so shaped that the coin rolls or glides through the chute without jars. The coin chute has two coin guides, adjustable for different diameters of coins and fixed with screws that are accessible when the cover of the chute is removed. The lower adjustable coin guide acts at the same time as gauge for the minimum diameter of the coin, undersize coins being thrown from the chute before they can act on the coin contact.

The coin contact is made as an oscillating contact with a vibrating spring which receives the impact of the coin. The spring is then set swinging and produces a series of contact makes in the telephone circuit, thus signalling to the operator at the exchange that a coin has been inserted in the instrument.

As stated, the coin inset in these instruments can be exchanged for a coin inset for automatic encashment on a future automatisation of the exchange. As the coin chute is also adjustable for different sizes of coin between 15 and 21 mm it can also be used on alteration of the charge for calls. It is only the slot in this instrument that is separate for each kind of coin.

The cash box of the instrument, Fig. 4, can be sealed and is moreover made with automatic locking of the coin slot when the coin box is taken from the instrument. Before replacing the coin box in the instrument the locking device must be set by moving the guiding pin of the locking plate by hand from locked position to opening position. The procedure is shown in Fig. 4. The coinbox opening will then remain closed until the box is again inserted in the instrument. The object of the automatic closing is to prevent the employees dealing with exchange of coinboxes from being tempted to pilfer coins from the coin box. In those subscriptions where the subscriber himself empties the cash box, there is used a funnel instead of coin box, this directing the coins to a hatch at bottom of the instrument. The instrument is emptied by unlocking it, whereupon the hatch is released and the coins fall out, Fig. 5.

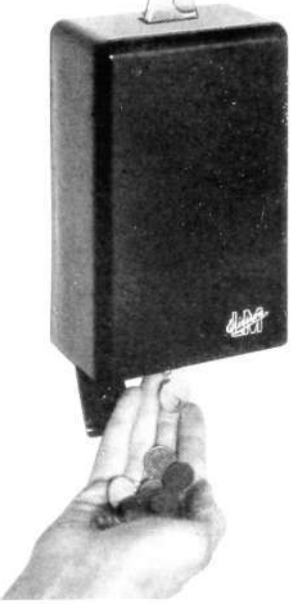

Fig. 5 X 4281

The subscriber, who himself empties the coin box, opens the hatch beneath the instrument with the key

Any type of telephone instrument may be connected to these coin box instruments. In L. B. systems the coin box instrument's oscillating contact is branched over the transmitter and transmits a buzzer tone to the operator when the coin is inserted. In C. B. systems this contact is connected to the line terminals of the telephone instrument.

Hallway Switchboard with XY-Selectors

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U.D.C. 621.395.262

For ordinary blocks of flats which do not generally contain more than thirty to forty appartments, the hallway telephone described in Ericsson Review No 4, 1934, has found wide employment. In recent years, however, buildings comprising up to several hundred flats have been erected and for these the said hallway telephone is not suitable, chiefly because the board of tenants' names becomes unwieldy and difficult to follow. For such big buildings L M Ericsson has designed a hallway switchboard with XY-selectors forming the connecting device.

The feature of the switchboard, which in principle functions as a local telephone plant, is that the tenants are not called by press buttons but like ordinary telephone subscribers by means of a dial and automatic connecting devices. Some of the instruments can only make outgoing calls to the room telephones installed in the flats, which in turn can only receive calls. The calls established over the hallway switchboard are secret and cannot be overheard by tenants not concerned. Several calls can be carried on simultaneously. It is therefore advisable to place several calling instruments in the hall, so that visitors need not queue up. Other instruments are located with the caretaker, the matron and other persons belonging to the serving staff who require to have the facility of telephoning to tenants. In this way the work of the staff is facilitated and the service to the tenants is improved. The room instruments, which are of the home telephone type, are fitted with devices for opening the hall door. All instruments are connected to the switchboard by two-wire lines. In addition, a common earth line is required for the room telephones.

As there are no call buttons, it is not necessary to take the hallway switchboard into account when preparing the list of tenants that must be set up in the main entrance. The most suitable method is to make the list in the

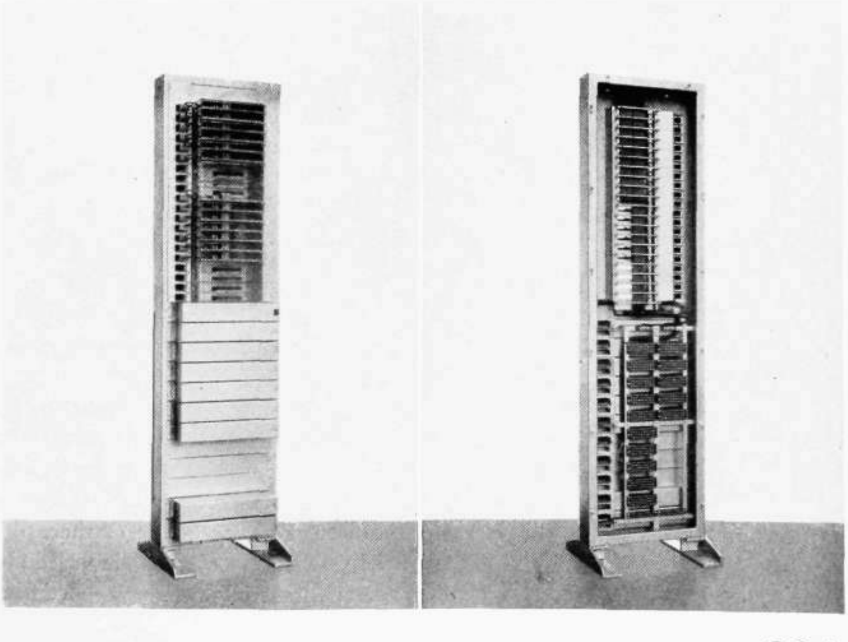

Fig. 1 X 5703

Hallway switchboard

for 400 lines and not more than 10 connecting circuits, arranged for 300 lines and 7 connecting circuits; left, front view, right, back view with cover removed

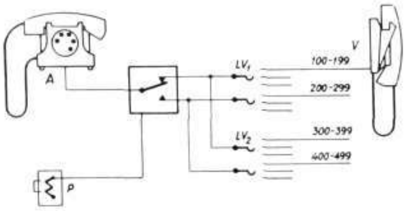

Fig. 2 X 4040
Skeleton diagram of 400-line hallway switchboard

A call instrument
LV_1 final selector
LV_2 final selector
P hall door lock
V room instrument

form of a board on the wall, with the names in alphabetical order followed by the three-figure call number which should be the same as the number of the flat.

The hallway switchboard is so constructed that a call instrument for visitors can be set up at several entrance doors. When the tenant unlocks the door, it is always the lock of the door from which the call comes that is opened.

The hallway switchboard is made in two sizes, a small one with facilities for not more than five simultaneous conversations and *220 flats*, and a larger one with facilities for up to ten simultaneous conversations and 400 flats. In the large type, Fig. 1, whose dimensions are: height 2000 mm, width 520 mm and depth 250 mm, the lower part of the rack contains the connecting circuit relay assemblies and right at the bottom a common unit comprising signal relays. The upper part of the rack holds the connecting circuit selectors with multiple. This last is divided into two parts, each for 200 extensions. Each connecting circuit has a four-pole 100-line XY selector in each multiple half. Behind the connecting circuits is a terminal block containing the terminals for connecting the line network. The outside cabling is led to the rack through a column in one of the side pieces. The selectors and relay assemblies are protected by dust-proof covers and the back of the rack by a complete sheet wallboard cover. Further particulars of the design of XY selectors and the construction of the frame are given in Ericsson Review No 1, 1938.

The call instruments are directly connected each to its own connecting circuit in the switchboard, see diagram Fig. 2. The doorlock for it is connected to the circuit or circuits belonging to the instruments located in that hall. The connecting process is briefly as follows: when the visitor has found the desired number, he lifts the hall instrument handset, receiving dialling tone at once. The desired three-figure number is dialled. If the tenant is free periodical buzzer signals are emitted from the room telephone. The caller hears ringing tone. When the tenant answers, the signals are disconnected and speech connection is established. If the door is to be opened, the tenant presses the switch-hook button on the instrument down to bottom. This earths one of the speaking wires. A differential relay is actuated in the connecting circuit and connects release current to the door-lock that is connected to the circuit.

If the tenant is busy with call the visitor receives busy tone. The connection is cleared when the hall instrument's handset is replaced. To prevent a tenant's telephone being blocked by a visitor having neglected to replace the handset, the connecting circuits are provided with a time release which after a certain time disconnects the extension and connects in busy tone to the hall instrument.

The two four-pole 100-line XY selectors pertaining to a connecting circuit have together a capacity of 400 extensions, as only two poles require to be used for connecting. Ordinarily an XY selector takes up only two figures. In the hallway switchboard, however, there is employed a special connection by which the one selector of the connecting circuit first executes a blind movement and marks the desired hundreds figure in a relay combination, after which the selector is restored. The relay combination determines which of the two selectors has to be set in X and Y movement by the two last figures.

The small switchboard type differs from the large one only in the rack being lower and each connecting circuit being equipped with one selector only. The traffic to the first 200 lines is executed in the same manner as with the 400-line switchboard. A further 2 × 10 lines is obtained by utilising the XY selector's home position multiple frame, which is connected in instead of the second 200-line group in the large switchboard. By transposing the connecting circuits it is possible to obtain different number series. Thus it is not necessary to fix the numbering at *100 — 499*, but *001 — 309*, for instance, can quite well be used. For one of the entrance doors, *e. g.*, the staff entrance it is possible if so desired to connect the circuits so that only one or more tens of flats — that is, the staff dwellings — can be called from the instrument there.

Telecommunications in the New Fire-Station at Brännkyrka, Stockholm

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U.D.C. 654.147.2

In an inquiry last year from the Stockholm Fire Service for an alarm telegraph installation at the new Brännkyrka fire-station, the specification called for a mobile central equipment. It should be possible to move the instruments installation easily and quickly from its normal position in the control room of the fire-station to a nearby bombproof shelter.

At the time of this inquiry L M Ericsson's standard equipment consisted of marble instrument panels mounted on walls or on the front of large cabinets, the telephone and telegraph equipment being fitted on a separate desk in front of the panels. As such a plant did not need the specification in question and partly also to modernize the exterior, it was decided to redesign the constructional lay-out completely.

This new design will in future be used as standard and a more detailed description may, therefore, be of interest.

Fire Telegraph Central

No circuit changes have been made and the alterations affect the mechanical construction and lay-out only.

The instruments, which were previously fitted on sloping panels, are now mounted in portable sloping desks, Fig. 1, in polished oak, one for each supervisory circuit (three loops).

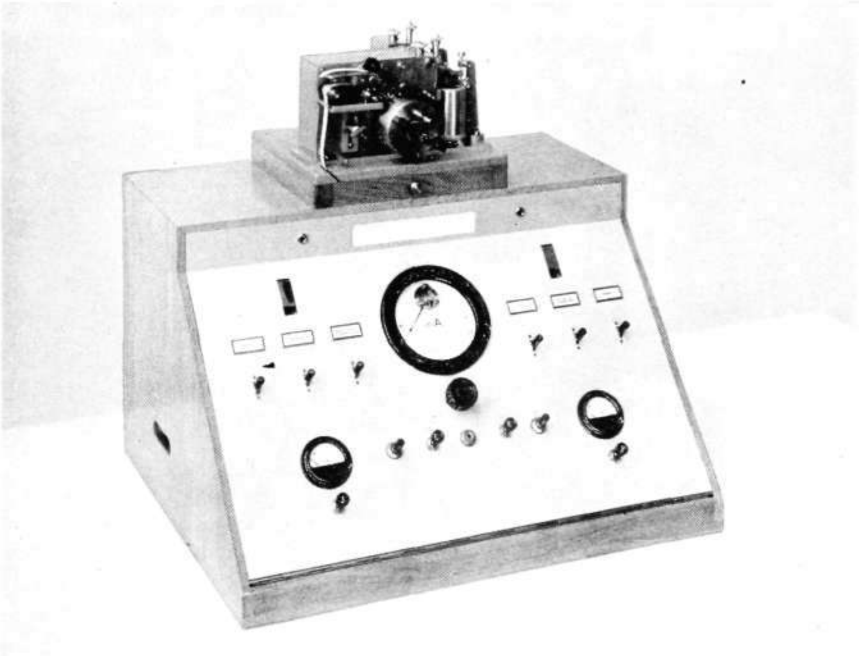


Fig. 1 X 6005
Portable line desk for fire telegraph

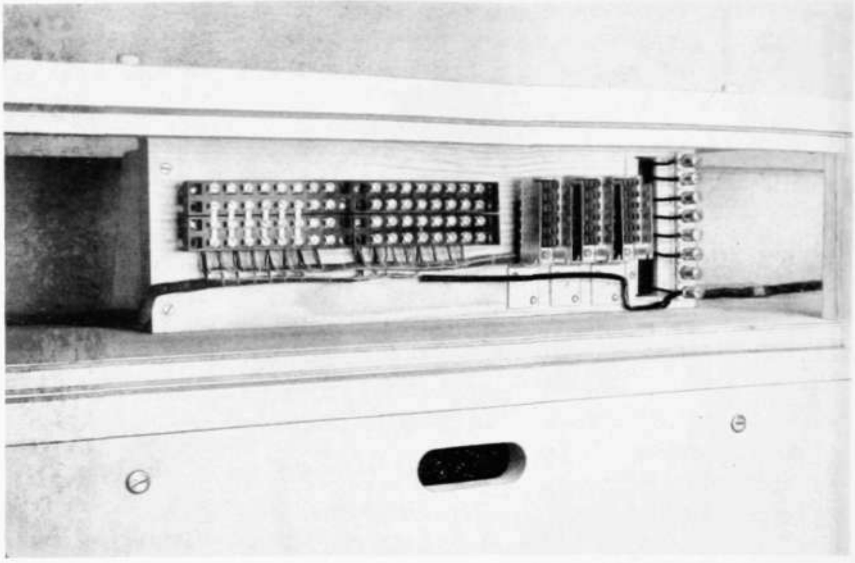


Fig. 2 X 6006
Jacks and terminal blocks in the fire-telegraph base

In front the desk has an instrument panel of enamelled sheet-metal. The panel, which can be swung down, is attached to the desk by hinges at the bottom and by two spring locks at the top. The locks are worked by two movable rods lying flush on the panel, which serve as supports when the panel is swung down.

Line fuses, arresters, bells and relays are fitted inside the desk. The fuses and bells are attached to a common base at the bottom of the desk. The relays are mounted on two bars, which are attached to two fittings on the sides of the desk at the back. To allow adjustment and inspection of the relays, the back of the desk is detachable.

The double telegraph instrument for the supervisory current circuit is mounted above the desk. The telegraphic paper strip is carried through slits in the top and bottom of the desk down to the base. The connections are led to eighteen-points plugs with leads. The plugs may be passed through a hole in the bottom of the desk for connection to jacks in the base. Strong four-point plugs are used for the fire-alarm box lines and for earth.

The base is made to serve the number of desks required in each individual case and may either stand free or against a wall. At the back of the base are a couple of brackets which grip a rim in the bottom of the desk when it is pushed in. At the front, the base has two pins which fit in holes in the desk bottom. The desk projects over the base sufficiently to allow of it being raised and drawn forward when it is to be moved. At each side of the desk there is a slot serving as grip for carrying. The size and weight of the desk are such that one man can carry it without difficulty.

In the upper part of the base front there is a hatch for each desk, behind which are fitted the jacks for the desk plugs together with terminals for incoming lines, battery lines and intermediate connections, see Fig. 2. The top of the base has a hole corresponding to the hole in the desk bottom for the passage of the plugs. The base may also be made without top, the desk then acting as cover.

The central apparatus base at the Brännkyrka station has place for four desks, see Fig. 3, three being intended for connection of fire-alarm box loops. The fourth is equipped with devices for telephone communication with the boxes and for measurement of insulation and resistance of the lines. There is also connected a repeater line to pass on incoming signals to the head station. This line is also utilized for telephone communication between the stations. The base in the fire-station telegraph room is of steel-tube construction, while that in the district central is of cellulose-enamelled yellow deal.

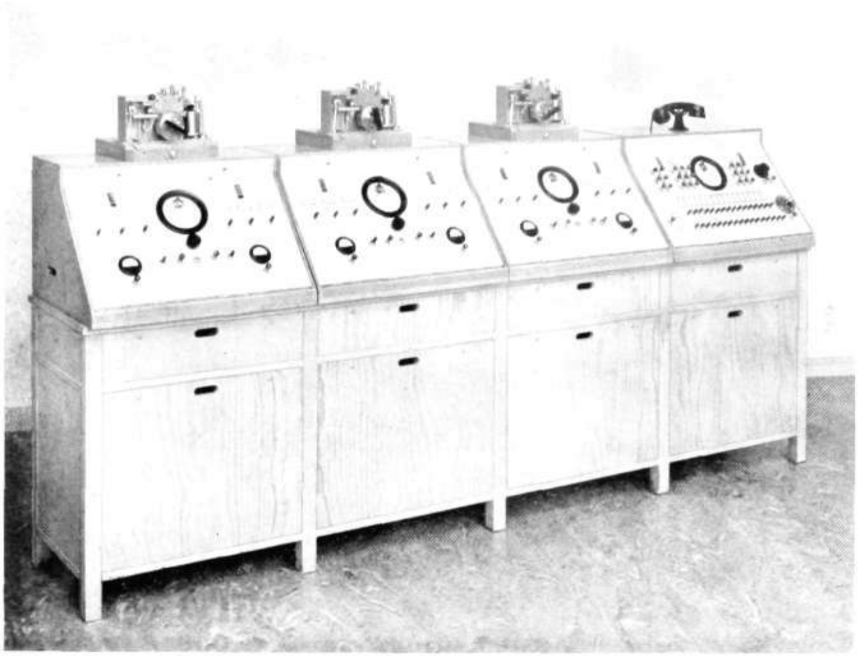


Fig. 3 X 6007

Central fire telegraph

with base and three desks for lines and one desk for telephone and test

Power Plant

The batteries for the installation are located in the basement. The instrument panel for charging and control of the batteries is built into a frame similar to that used in our large automatic fire-alarm installations. It is inserted in the telegraph room wall to the right of the fire-telegraph desk.

Automatic Fire-Alarm Plant

Located at the left of the desk is the central apparatus for the station internal automatic fire-alarm plant, inset in the wall in similar manner, see Fig. 4. To this are connected thermo-contacts for the main building basements, basement stores and attics, the basements and attics of the living quarters and the ground-floor and attics of the training quarters.

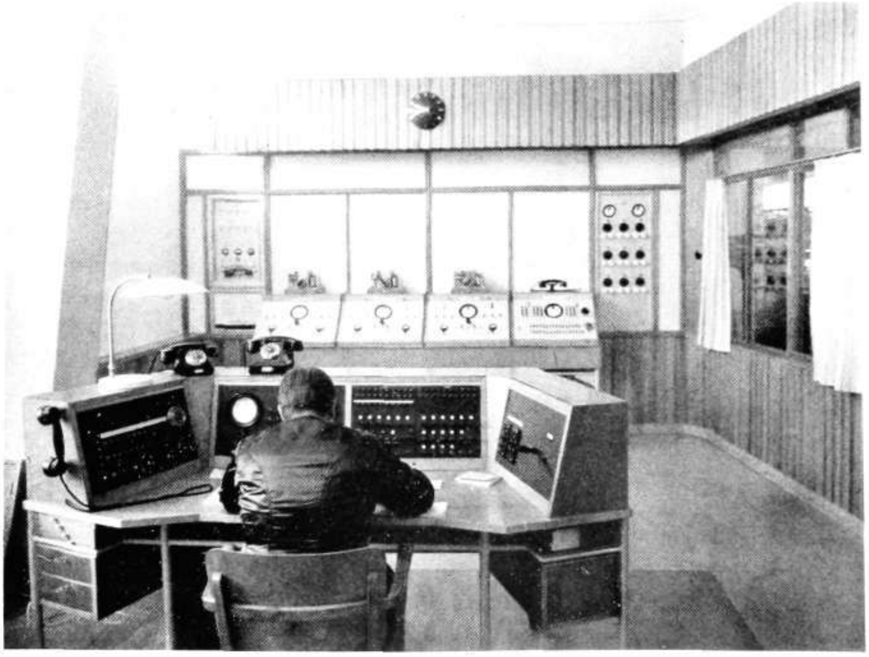


Fig. 4 X 6009

Telegraph room at Brännkyrka fire-station

in foreground: control desk. In background: fire telegraph central with charging panel inserted in wall to the right and the automatic fire-alarm central to the left.

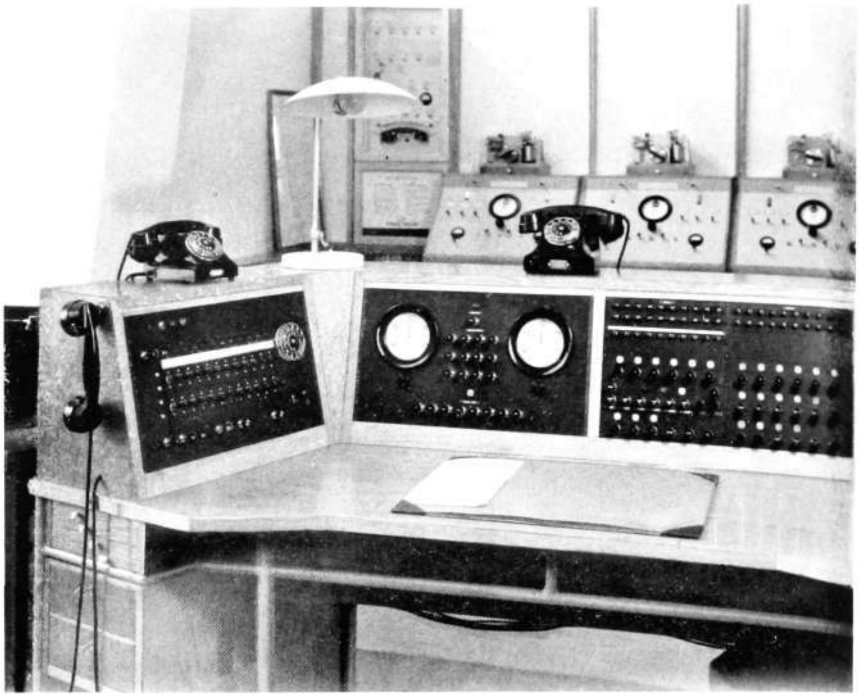


Fig. 5 X 6010
Control desk

with public exchange telephone at left. In middle: panel for turn-out control and keyset for station alarm. At left, keyset for marking quarters to be called for chimney fires and ambulance calls, keyset for turn-out boards in engine hall etc.

Intercommunication Telephone

There is an automatic telephone switchboard for internal telephone traffic, over which calls can be established with the fire-alarm boxes. For this purpose there is a switchboard line connected to the fourth desk of the fire telegraph over a special relay device, see Fig. 3. This is furnished with a dial by means of which the telephone operator can call the required extension in the station, after which this extension may be switched on to the calling fire-alarm box loop.

Public Exchange Telephone

External telephone traffic is handled by the telephone operator over a manual C.B.-P.B.X. fitted in an operating desk in the telegraph room. This contains also devices for giving alarm and signalling inside the station, turn-out control, staff location etc., see Fig. 5.

Alarm and Signalling Inside the Station

Inside the station there are eighteen living quarters, each intended for two firemen. In these quarters, as also in common rooms, corridors etc. and outdoors, there are both audible and visible devices for alarm and signalling, these being operated from a keyset in the control desk.

In the living quarters the signal devices, consisting of two A.C. bells, an A.C. buzzer and 3 signal lamps are mounted above the door in a special recess which also contains an operating relay for each lamp, see Fig. 6. The lamps are mounted in front of different coloured reflectors, one red, one green and one white. One bell has tubular gongs, the other ordinary dome gongs. In all indoor rooms similar signal devices are to be found. For the visible signalling, however, there are no separate lamps, those on the staff-locator boards being used, these comprising three lamps of the same colours as the reflectors behind the lamps set up in the living quarters.

Outdoors there are two bells with tubular gongs and two with dome gongs in watertight construction, KLD 6402 and KLD 6303 respectively, and, in place of buzzers, two bells KLD 3004. The A.C. bells receive current from the signal battery over a converter. In addition as reserve a hand generator is mounted in the control desk. The current feed is switched automatically over from converter to generator when the latter generates current. As control over converter and generator, a relay with rectifier has been inserted on the A.C. side, this lighting a pilot lamp in the control desk. The buzzers are fed from the lighting mains over a transformer.

The lamps in the men's quarters receive current direct from the lighting mains, while the lamps in the locator boards are fed from the mains over a transformer.

The audible signal circuits are operated via a code-signal transmitter comprising a number of relays and selectors, by means of which the signal devices are made to give different code-signals. One signal device, therefore, can be employed for several different alarm signals.

When fire-alarm signals come in to the station, whether via the fire-telegraph or per telephone, the telegraph attendant presses the button for *fire-alarm* in the control desk keyset. This starts up the converter and all bells with tubular gongs receive current and ring uninterruptedly for about 20 s (time governed by the code-signal transmitter). In addition all lamps before red reflectors in all the men's quarters light up, while in other places the red lamps in the locators are lit. Moreover, circuit is closed for four lighting groups for lighting in corridors, staircases, vehicle hall etc. The gong relays for the lighting are broken automatically after 60 to 120 s by a time relay.

For *chimney fires* alarm is given on all bells with dome gongs except in the men's quarters, only those quarters concerned with the alarm receiving signal. As with fire-alarm, the bells keep on ringing for about 20 s. In quarters and on lamp boards the green lamps light up. In this case only three of the lighting groups are switched on.

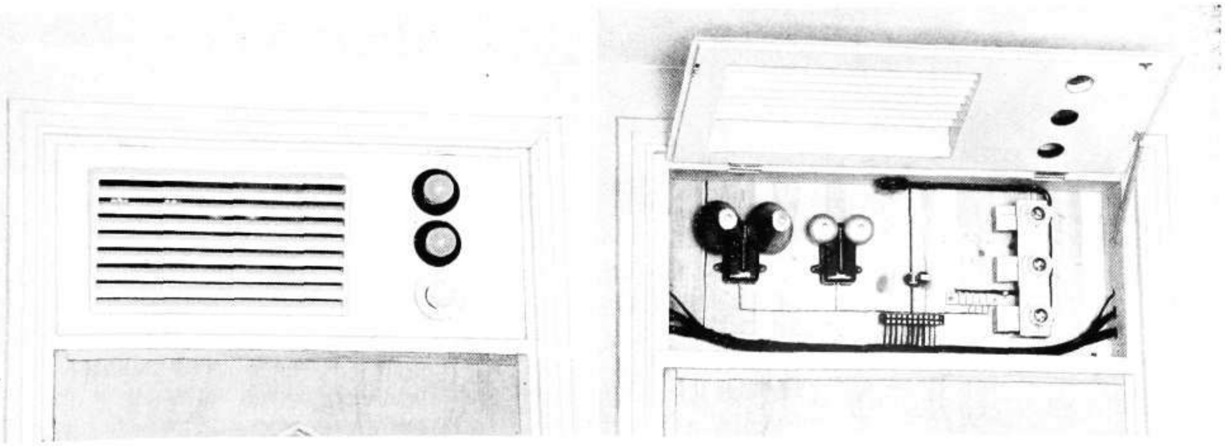
To give alarm for *emergency ambulance* the signal is the same as for chimney fire, but the bells ring with repeated short signals instead of uninterruptedly.

Signals for *ordinary ambulance* and for *accidents* are given by all buzzers except those in the quarters, where, as for chimney fires, only those quarters concerned receive signal which is marked in another keyset of the control. For ambulance the buzzers sound continuously for about 15 s and for accident they give repeated short signals. In quarters and on lamp boards the white lamps are lighted. Only two lamp groups are lighted for these signals.

Command alarm, i. e., alarm for the brigade captain only, is made on the A.C. bells with dome gongs, but not in the quarters, and by a buzzer in the captain's room and a signal horn in the yard. The signal is given twice, app. 2 s signal and 1 s interval. In addition three of the lighting groups are lighted. This command signal is required when the captain of the fire-brigade is duty officer, to be called out on alarm to another station than his own.

The control desk signalling keyset also includes a key for *cancelling*, indicating that a signal given for turning out is to be annulled. This signal goes out on a motor-siren mounted outdoors. In addition, a red lamp lights up in the

Fig. 6 X 7359
Recess with alarm signal devices above doorway in living quarters



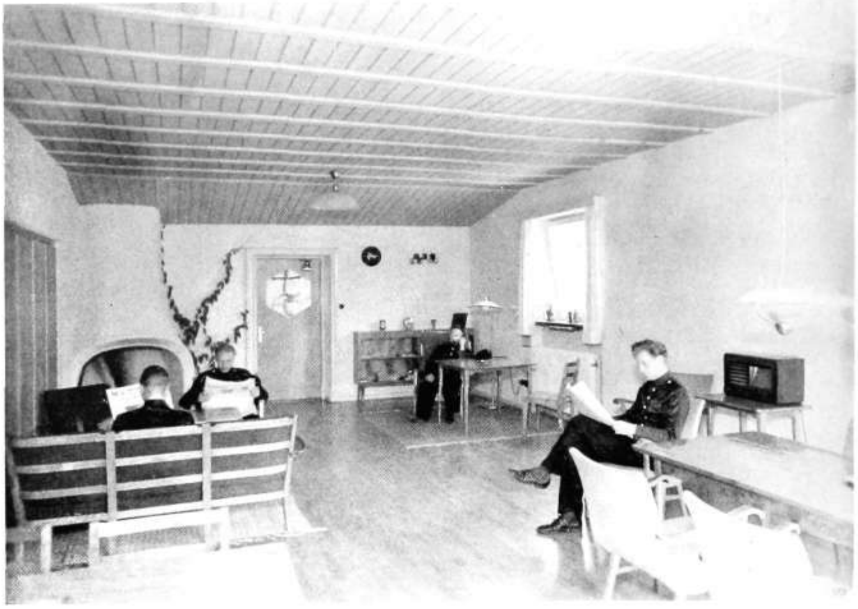


Fig. 7 X 6011

Common room

The signal device for internal alarm in the background, to the right of the clock

vehicle hall, which keeps shining with fixed light for 30 s. Should the cancelment not apply to all the vehicles concerned in the alarm, there is only the red light and no audible signal. For this there is a special button in the keyset.

For testing the code-signal transmitter and the audible signal devices there is a test button in the control desk keyset. On testing, this button is first pressed and then the signal button for the signal device to be tested. Test signals consisting of three signals app. 0.5 s long, followed by one signal app. 5 s long are then sent out via the code signal transmitter on the signal device concerned.

For restoration or interruption of any of the above signals there is a restoring key in the keyset.

In the event of failure of the code signal transmitter, it is possible also to *give signals manually by means of special buttons in the control desk.* There are also buttons for separate switching one of the four lighting groups, for starting the ringing current converter and for starting suction fans for clearing exhaust fumes in the vehicle hall. In addition there are pilot lamps for the above keys in the control desk, which light up when the corresponding keys are pressed.

Turn-out Board and Turn-out Control

To indicate which of the vehicles shall turn out there are set up in the vehicle hall in front of each of the two drive-out doorways two lamps which are lighted by means of press-buttons in the control desk. For each of the buttons there is a pilot lamp coupled in series with the corresponding lamp in the vehicle hall and for insurance also coupled in parallel with a resistance. The one lamp is lighted when only the motor fire-engine shall turn out. If trailer is to be added then both lamps light. Current feed is from the lighting mains over a transformer.

The turn-out check consists of two stop-clocks with electrical starting and stopping device but manual zero restoration. The first clock is started via the fire-telegraph signal relay immediately signal comes in from a fire-alarm box. It stops when the telegraph attendant presses the fire-alarm press-button to alarm the station. At that moment the other clock starts and it only stops when the first vehicle to turn out leaves the station. The stopping of the latter clock is produced by a circuit, going through floor contacts in the vehicle hall, being broken as the first vehicle passes over that contact, Fig. 8. Thus

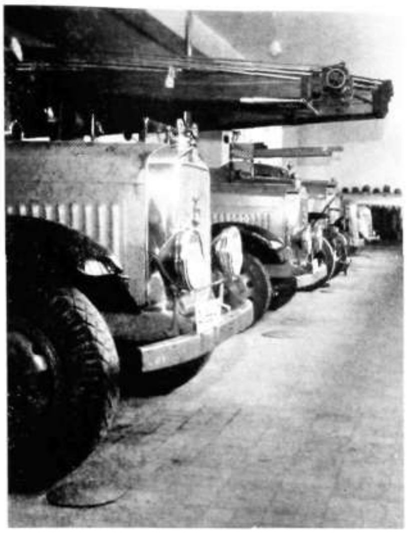


Fig. 8 X 4291
Floor contacts for turn-out control in front of cars in the hall

on the first clock it is possible to read the time taken by the telegraph attendant to give the alarm from the arrival of the alarm signal at the station. On the other the interval of time between the giving of alarm in the station and the departure of the first vehicle can be read. Both clocks give the times in seconds.

The time of arrival of the signal is recorded at Johannes fire station, the head station, where it is stamped on the strip of a telegraph apparatus common to all stations, which also records the number of the fire-alarm box giving the alarm. The transmission from Brännkyrka to Johannes takes place over the junction line connected to the fourth desk of the fire telegraph, mentioned above.

Traffic Signals

To facilitate the drive-out there are two traffic lights with red light, mounted on a pole outside the station. These are lighted and extinguished manually from the control desk.

Staff Locator Installation

For staff location inside the station there is a keyset in the control desk, by means of which various lamp combinations can be lighted on the lamp boards containing three lamps set up in corridors, common rooms etc. Location is done by flashing light. As stated above these lamp boards are also employed for alarm signalling, indicated by fixed light.

Clock Installation

On the various premises of the station there are twelve secondary clocks, driven by minute impulses from a master-clock with $^3/_4$ s pendulum and automatic electrical winding.

Line Network

The fire-telegraph loops are for the most part laid in underground cables drawn to the bombproof district central. There they are branched to the terminals for the fire telegraph in the district central and via an underground cable to the fire-station fire telegraph. The underground cable from the district central to the fire station terminates in a cable box, whence cables are led to the fire-telegraph base. The underground cable and the lastnamed cables have separate terminal blocks. The corresponding clamps of the blocks are coupled together in parallel.

For removal of the fire telegraph to the district central the fire-station cables can rapidly be disconnected from the underground cable by clipping off the parallel connections between the terminal blocks. In this way disturbance of the fire-telegraph is avoided in the event of line fault inside the fire-station owing to bombing or the like.

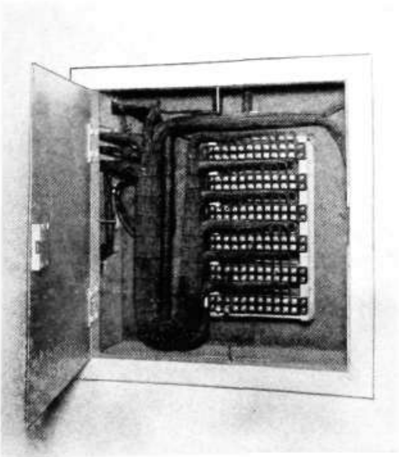


Fig. 9 X 4290
Distribution box for internal alarm lines

The weak current lines for alarm and signal inside the station are branched in special distribution boxes, Fig. 9. These consist of a recess embedded in the wall, having a door behind which the terminal blocks are mounted on a swing-out grid. This provides a very neat and accessible mounting, facilitating fault location to a high degree.

L M Ericsson's Remote Indicator System for D.C.

C AHLBERG, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

U.D.C. 654.915.2-83

The demand for remote indicators has long existed and many systems are to be found on the market. L M Ericsson has worked out a D.C. operated remote indicator system which can be employed for locator and order-giving plants as also for marking and reporting plants. The lines used for this system are three-wire and of the same dimensions as for ordinary telephone lines.

Principle

In principle the system consists of a transmitter, a three-wire line and one or more parallel-coupled receivers. Fig. 1 a and b show a skeleton diagram of the principle. *E* is a D.C. source of current, *1*, *2* and *3* are brushes which wipe four fixed contact segments. These lie in two pairs diametrically opposite each other. In one pair each segment comprises five-twelfths of a revolution and is connected with the plus or minus pole respectively. In the other pair each segment represents a one-twelfth revolution and is entirely insulated. The three wipers are connected each with a line branch and on rotation of the transmitter they connect these in turn with the plus pole, insulate them and connect them with the minus pole as is shown by the diagrams.

The receiver *M* consists of a permanent magnet *NS* which can rotate under the action of the field from three electro-magnets. These are arranged symmetrically around the magnet's axis and at an angle of 120 degrees in relation to each other. The corresponding winding ends of the magnet coils, for instance the starting ends, are connected up together while the free ends form external connections and are coupled each to one branch of the three-wire line.

In Fig. 1 a the transmitter *G* stands in position 1 and all windings of the receiver are traversed by the currents I_1, I_2 and I_3. These produce magnetic fields Φ_1, Φ_2 and Φ_3 with the directions given by the arrows. The magnet *NS* then takes up a position in the direction shown.

In Fig. 1 b the transmitter stands in position 2. The receiver windings I and III are traversed by the currents I_1 and I_3 respectively, these now being equal, while the winding II is without current. The magnetic fields Φ_1 and Φ_3 of the coils set the magnet in position 2.

The transmitter wipers can be put in twelve positions, which are represented by twelve combinations of currents in the three-line branches and the receiver windings. The receiver magnet will thereby take up twelve positions, each one corresponding to the position at that moment of the transmitter. Should the current be interrupted while the transmitter is being rotated, the receiver will stop until the current returns and will then take up the same position as the transmitter.

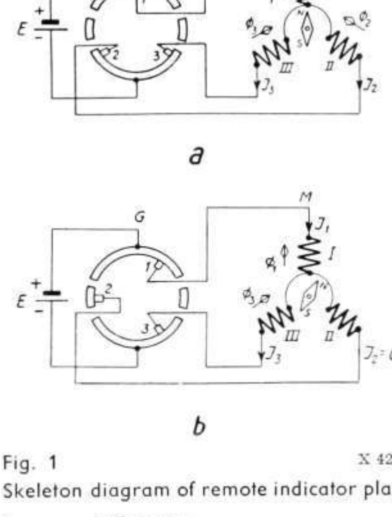


Fig. 1 X 4262

Skeleton diagram of remote indicator plant

E	D.C. source
G	transmitter
I_1, I_2, I_3	electric circuits
M	receiver
NS	magnet
Φ_1, Φ_2, Φ_3	magnet fields
1, 2, 3	wipers
I, II, III	windings

The currents from *E* pass through the receiver windings in different directions for different positions of the transmitter. The permanent magnet takes up a position in the direction of the resulting field.

The Receiver

Fig. 2 shows the design of the receiver. The magnet coils are arranged one above the other and at an angle of 120° in relation to each other. Each magnet coil, wound direct on its iron core, is provided with two pole-shoes. The six pole-shoes form together a six-sided prism. In that part of the prism that is

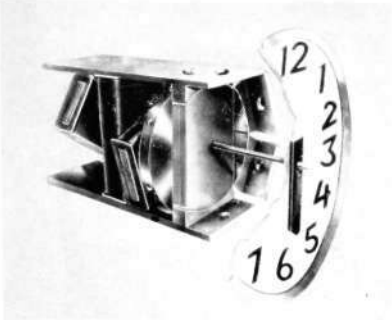


Fig. 2 X 4268
Section of the receiver

not taken up by the magnet coils the rotary magnet lies on its shaft. The shaft is pivoted in ball-bearings in two housings. One axle pin projects from the outer housing and can be fitted with pointer, cogged gear, worm gear or other gearing to a pointer or the like. In Fig. 2 two pole-shoes and the outer bearing housing are removed as also a part of the dial.

The above arrangement of the magnetic fields gives a particularly compact construction while the magnet coils are inexpensive to wind and have large winding space. In this way the rotation moment of the shaft is large in relation to the power input, app. 60 gcm with 0.6 W and 90° rotation of the shaft from a home position.

As the resistance in the magnetic fields of the coils is mainly represented by the resistance of the air gap, the difference in the effective length of the pole-shoes plays but a small part in the values of the fluxes Φ_1, Φ_2 and Φ_3. A small unevenness in the air gap has a larger effect but can easily be compensated by thin partitions of none-magnetic material between the coil ends and the pole-shoes.

Fig. 3 and 4 show a remote indicator mechanism KCT 10. The coils are fixed between the pole-shoes by the screws seen, two for each pole-shoe. The screws fix the pole-shoes to the bearing housings. In the outer bearing housing there are three threaded holes constituting attachment for dial or the like. In the other end of the prism a terminal block is fixed to two pole-shoes as shown by Fig. 4.

The dimensions of the mechanism are: total length excluding shaft-pin 62 mm, greatest diameter 49 mm.

Fig. 5, 6 and 7 show different forms of receivers. The receiver in Fig. 5 is made as a panel instrument for flush mounting. The dial diameter is 80 mm. The receiver is intended as order receiver for power stations, saw mills, dairies, ships etc.

The receiver in Fig. 6 has 300 mm dial and the same range of employment as the preceding but is, with the position marking shown, specially designed as staff locator. Figures for minutes have been chosen to prevent confusion with an ordinary clock, which either has hour figures or hour strokes as position markings. On the other hand a similarity to the ordinary clock facilitates the picking out of a person's number on the dial. The persons concerned receive minute-hand figures as identifications.

Fig. 7 shows a staff locator receiver for placing on tables. The figures are replaced by hour strokes. The capacity has been doubled by the introduction of a shutter operated over special line-pairs. When this shutter shows black the twelve positions on the dial represent different persons then when it shows white. The receiver case is made of wood and it is furnished with wall terminal

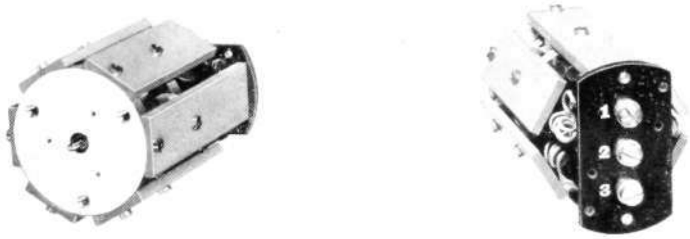
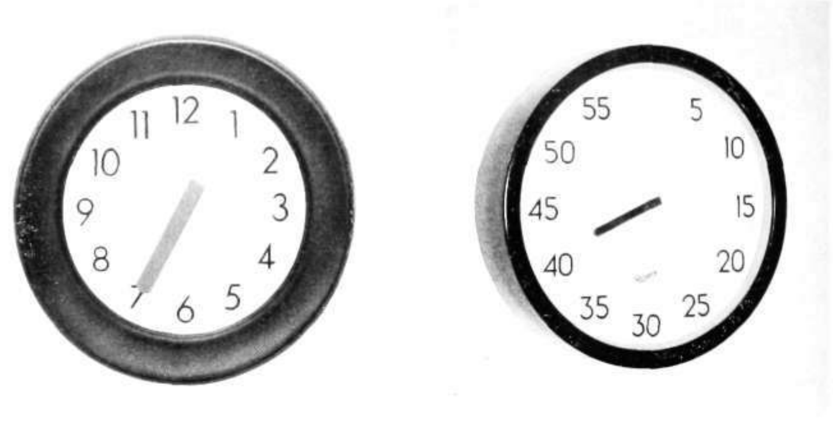


Fig. 3 & 4 X 4264 X 4269
Remote indicator mechanism KCT 10

left, seen from shaft side, right, from connection side



X 4265
X 4266

Fig. 5 & 6
Remote indicator receivers
left, for panel mounting; right, for wall mounting

and five-wire wall terminal cord. The shutter is also utilized to give a discreet audible signal when the pointer is moved. The transmitter sends out current impulses to the shutter as it rotates. This will be described later.

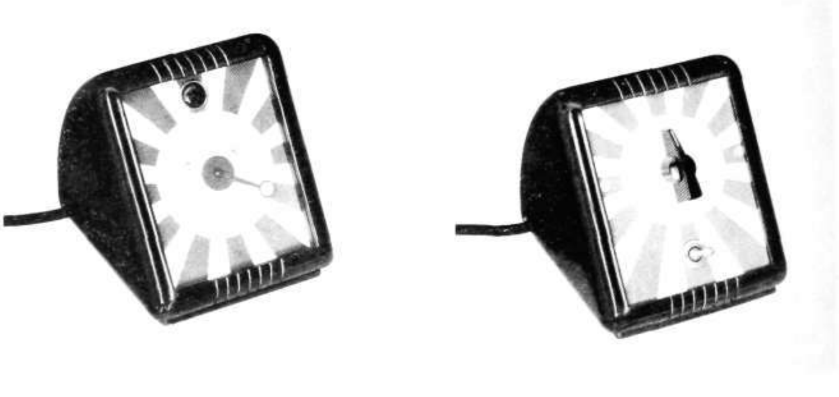
Obviously other audible signal devices could be used with the receiver. These, however, could not be connected to any branch of the three-wire line, unless superimposed A.C. is employed for their operation.

Transmitter

The transmitter is not made as shown on the diagrams Fig. 1 a and b, but in a simpler manner as per Fig. 9 a. The wipers and contact segments in Fig. 1 have been replaced by three spring assemblies acted on by a cam-disc with three different radii. The function may be seen without necessity for description from Fig. 9 a and b, the latter showing a cam-disc rotated one-twelfth revolution clockwise.

For centring the cam-disc in its twelve positions there is arranged on the same shaft a further cam-disc with twelve notches as per Fig. 9 a. Against the disc rests a centring spring which also forms part of a spring assembly. This assembly is, as shown by the figure, coupled to a switch *O*, by means of which the visual indicators in the above-described table receivers can be operated. Irrespective of the position of the switch the centring spring assembly sends out current impulses on the line 4—5 when the transmitter is rotated, either in the form of circuit makes or circuit breaks. In either case the shutters click and draw attention to the receivers.

Fig. 10 shows the transmitter mechanism. It is easy to distinguish the four spring assemblies and the two cam-discs. Concealed behind the middle spring assemblies lies the switch. A terminal block for the plus and minus poles, three line branches and the three poles of the switch is fitted on the end of the transmitter. The depth of the transmitter from the inside of the fixing plate is 93 mm and the greatest radial measurement, taken from the centre shaft's projection is 48 mm. The transmitter mechanism can be mounted in an instrument panel, inset in walls and so on.



X 4270
X 4271

Fig. 7 & 8
Receiver and transmitter for staff locator
with capacity doubled by means of switch

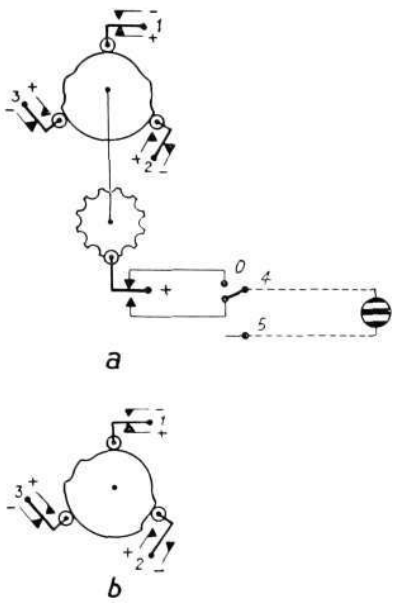


Fig. 9 X 4273

Skeleton diagram of transmitter

In Fig. b the cam disc has been rotated one-twelfth revolution from the position in Fig. a

O	switch
1, 2, 3	spring assemblies
4, 5	line

Working Tension, Line Resistance, Number of Receivers

The receivers are intended to be coupled in parallel on the three-wire line. Usually they are distributed fairly evenly over the whole length of line. The more receivers there are the smaller the overall permissible line resistance, *i. e.*, the shorter a line of a given dimensions must be. On the other hand the length of line can be considerably increased if the working tension is raised.

Two types of receivers have been standardized, *viz.* one for 24 V and one for 48 V, with coil resistances 110 and 450 ohms respectively. The following table gives a few examples of maximum line resistance, line length and number of receivers for tensions 20 and 40 V, *i. e.*, nominal 24 and 48 V.

number of receivers	max. resistance per single conductor ohm	max. line length in m	
		0.8 mm iron wire 0.215 ohm/m	0.5 mm copper wire 0.09 ohm/m
24 V system (20 V)			
1	110	510	1220
2	74	345	825
3	55	255	610
4	44.5	207	495
5	37	172	410
6	31.5	146	350
7	27.5	128	305
8	24.5	114	273
9	22	102	245
10	20	93	223
48 V system (40 V)			
1	445	2070	4950
5	148	680	1650
10	81	375	900
15	55.5	258	620
20	42	195	470
25	34	158	380
30	28.5	132	316

Current Consumption

As shown by Fig. 1 the current consumption is greatest when the transmitter is in position 1 or in another position with odd number. This should therefore be taken into account when computing current consumption.

If the plant consists of transmitter and one receiver only the computation is easy to make. If the plant comprises many receivers the computation will be more complicated. It is advisable therefore to calculate as if all receivers were connected without line resistance to the current source and the current drain from this will be for the 24 V type 0.145 A times the number of receivers and for the 48 V type 0.071 A times that number.

In consideration of heating the receiver should not be subjected to greater power than 4 W, with which the temperature in the hottest winding will be app. 45° C. This maximum power corresponds to 26 and 52 V tension applied to the 24 and 48 V types respectively.

Range of Employment

As stated above the apparatus described may be used in staff locator or order-giving plants. These plants in principle consist of one transmitter and several receivers. On the other hand there are plants with one receiver and several transmitters, *i. e.*, marking or reporting plants. Each transmitter will then have its separate three-wire line to the common receiver. For receiving of reports the receiver is connected to the line concerned and then takes up the same position as the transmitter. Knowing the significance of the positions it is possible to make out the report.

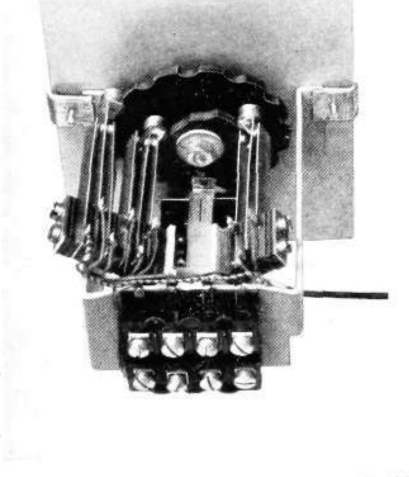


Fig. 10 X 4267

Transmitter mechanism

seen from the connecting side

Dial Operated Centralographs

A. HEDÉN, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

U.D.C. 654.937.2

The centralograph is to-day finding more and more uses in industry, being a valuable and sometimes indispensable means of increasing efficiency and supervising the continuity of processes. In order to cover the new demands which have arisen through this wider use, a new centralograph has been developed which, with several improvements in the principal design and a more modern exterior, contains some essentially new features.

When controlling the running of a machine it is important to record not only the time when the machine has been working but also the reasons for stoppages and interruptions. With the old design no information could be obtained from the diagram on this point and the stoppages showed simply as »white patches». Such a diagram had to be supplemented by means of written reports from the machine operator, a method which naturally was rather unreliable. The new design aims, therefore, in the first place at overcoming this difficulty.

The recording proceeds on the same principles as in the old centralograph but alongside the strokes, and independent of them, figures can be stamped. The figures, which for each particular case can be given suitable meaning respecting stoppage of operation and the like, are stamped by the corresponding figure being taken on the dial placed on the machine concerned. Consequently the machine attendant immediately interruption of operation occurs can report the reason, and a glance at the diagram will at once show not only *when* but also *why* stoppage occurred, see Fig. 1. In the diagram given, the following code has been applied:

1 = change of order
2 = setting up
3 = trial running
4 = machine fault
5 = waiting for material
6 = machine unattended
7 = greasing and cleaning
8 = resetting for dimensions
9 = other stoppages
0 = — —

For example, machine No 1 was stopped at 8.43 a. m. for change of order (1). After that greasing and cleaning (7) were undertaken, then setting up for new order was begun 8.55 a. m. (2). Trial running (3) proceeded until 9.12 a. m., after which the machine was again run normally until 10.22 a. m., when the work for this order was completed (1 change of order).

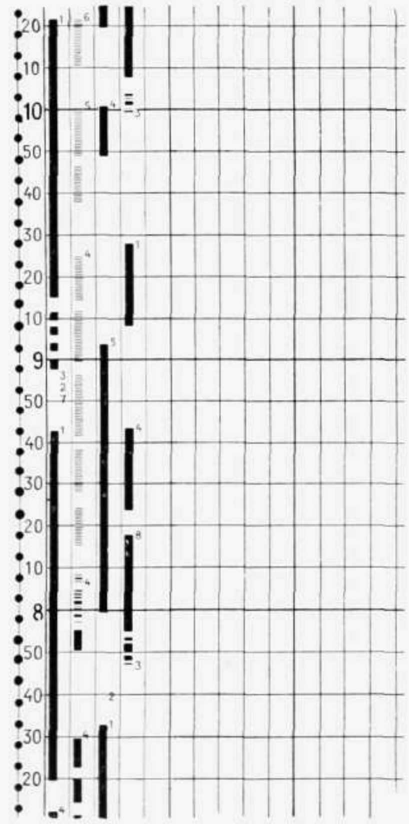


Fig. 1 X 4289

Portion of centralograph diagram

with figure stamping. The code to be used for reporting is adapted to the conditions prevailing in the undertaking concerned.

Design

The new centralograph has been produced in two types, *viz.:* KCE 10 with possibility for stroke and figure stamping for up to 20 lines and KCE 11 with possibility for stroke stamping only for up to 30 lines. The later type therefore replaces the former centralograph with catalogue designation KI 101 and KI 201.

The centralograph, the appearance of which is seen on Fig. 2, is in frost-finished green enamel and the shaping of the hood is on up-to-date principles. The apparatus is intended for mounting on the wall and is attached at the top by a large screw in the middle and at the bottom by two smaller screws. Mounting is a simple matter after the hood has been removed and the chassis swung out, as shown by Fig. 2. Both KCE 10 and KCE 11 are made for driving either by synchronous motor or impulse motor. The method of driving determines the article number as below.

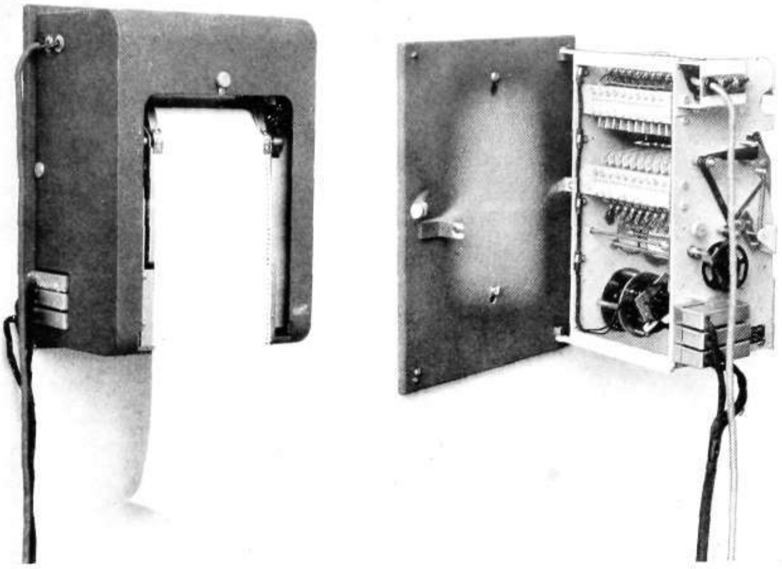


Fig. 2 X 6004
Centralograph
right, with chassis swung out

KCE 1011, KCE 1111	Impulse motor 24 V 3/4 s
KCE 1012, KCE 1112	Impulse motor 24 V 1/1 s
KCE 1013, KCE 1113	Synchronous motor 110, 127, 220 V 50 c/s

Connection of the synchronous motor to the mains is made with fixed lead having ordinary plug contact, while the pole-changed impulse voltage to the impulse motor is connected direct to its terminal block. For this lead there is a slot in the lower edge of the back-plate. The diagram lamp described below is also connected to the above named fixed lead. There are separate switches, see Fig. 2, for the driving motor and lamp.

The lines from the different impulsing devices and the D.C. voltage required to operate the stamping devices are connected by 18-point plugs and jacks, the jacks being fitted on the left-hand side of the centralograph. The plugs with lead form the terminals of the additional equipment required for the normal employment of the centralograph, but for special requirements there is a connecting box KCY 9002 consisting of a coupling case NEC 6002 with about 1.5 m cable terminating in three 18-point plugs.

Paper feed

The design of the paper feed in conjunction with the shaping of the hood and its window provides a complete survey of the whole diagram and, because of a reflector behind the stamping cylinder and a lamp above, it is possible to read the recordings a very short time after they have been made. The front plate of the paper holder enables notes to be made on the diagram without disturbing the feed of the paper. The diagram paper made in conformity with DIN standards is divided into 20 columns 6 mm wide. The recording is therefore 120 mm and the total width 140 mm. The time divisions are such that they answer to 6 different paper speeds, *viz.:* 30, 60, 120, 300, 600 and 1200 mm/h. The different speeds are obtained by changing gear wheels in a gear box from the outside of the right hand side.

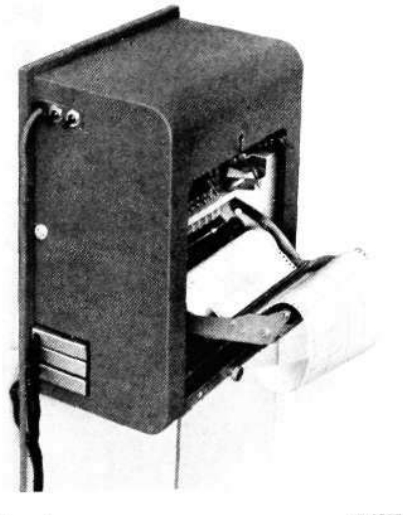


Fig. 3 X 4287
Fresh diagram paper can easily be put in the centralograph after the paper holder has been let down

When a fresh roll of diagram paper is to be inserted, the two arms which hold the paper against the toothed cylinder are raised, after which the paper holder can be let down. The fresh roll is then easily laid in its groove after being threaded into the cylinder, see Fig. 3. The paper holder is then raised, which automatically locks it in correct position, and at the same time the two above mentioned arms are replaced. Setting to correct time is done by rotating the geared cylinder, the movement of which from the motor is transmitted by a friction clutch, and setting is done in relation to a pointer at the left. The pointer, visible through a window in the left side, indicates how much paper remains on the roll. A full roll consists of app. 25 m paper.

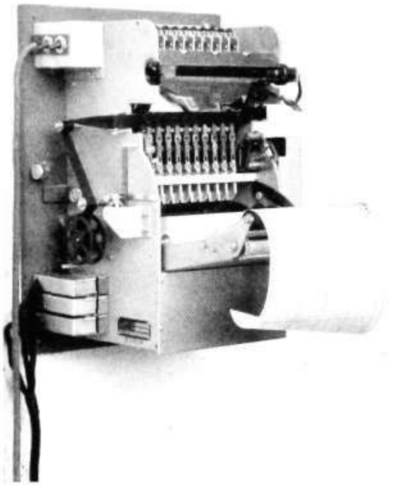


Fig. 4 X 4286

Centralograph

with hood removed and paper-holder let down. The threading of the ribbon may also be seen.

Ribbon feed

Stamping of figures and strokes is done by type and ribbon as in the old centralograph. The ribbon, of standard typewriter pattern, is fed continuously in front of the stamping cylinder at a speed that is always definitely related to the fixed paper speed. It is reversed automatically when one of the ribbon reels empties. In this way the reversing is independent of the length of the ribbon and it can be utilized to the full.

Change of ribbon is a simple matter after the hood is removed and the paper holder let down. Fig. 4 shows the ribbon passing from the left hand reel over guide rollers and in front of the stamping device. The arrangement is the same on the other side.

Stamping devices

The devices for stamping of figures and strokes are built up as stamping units of which there are two types, *viz.* 206308 for stroke and figure stamping and 222574 for stroke stamping only, see Fig. 5. The former is a stamping device for one line with provision for figure stamping and the later for two lines without such provision. In the centralograph there is space for 20 stamping units, arranged in two rows behind the stamping cylinder. The insertion of the units is very simple and attachment is by two screws only.

The units are subjected to very careful adjustment which, besides test of operation, includes fitting and locking of the fixing angle in relation to the spot the types for stroke or figure have to reach. This means that on insertion of the unit in the centralograph very little adjustment is required to ensure that stamping should be done with the requisite clearness at the right spot.

Owing to the dividing the stamping devices into units and the simpleness of their insertion it is possible to build the centralograph for almost any capacity from 1 to 30 lines. Moreover replacement of faulty stamping devices or addition to capacity can be done on the spot.

The stamping units are built on a frame of sheet-iron which lies in the magnetic fields of two electro-magnets. In stamping unit 206308 the armature of the magnet is shaped as an arm, the stamping arm, in the outer end of which a cast type-wheel with the figures 1—0 is pivoted. Alongside the type-wheel and level with its periphery one part of the stamping arm is shaped as a stroke type. The type-wheel, which is held in home position by a spiral spring, is moved forward step by step by a ratchet which is pivoted in the armature

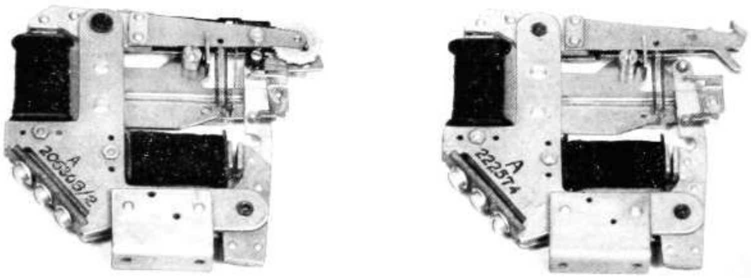


Fig. 5 X 6003

Stamping units

left, for stroke and figure stamping, right, for stroke stamping only shaped as feed arm on the second magnet. When the stamping magnet attracts and the type-wheel is at rest only a stroke is stamped and when the type-wheel is moved forward only a figure. When the figure magnet first attracts, the type-wheel is moved forward one step and the support of a stop spring is moved aside so that this falls and holds the type-wheel in its forward position. Each time the figure magnet attracts, the type-wheel is moved forward one step and the figure in stamping position will correspond to the number of impulses the figure magnet has received. When the stamping magnet now attracts, the figure is stamped and the support for the stop spring is restored to its original position so that when the stamping magnet armature falls the stop spring is raised from the type-wheel which then returns to home position.

The unit for stroke stamping only is built up in the same way as above but in this case the »figure magnet» armature has also been shaped as a stamping arm which actuates a stroke type via a link system. These two strokes are stamped side by side in the same column.

The magnetic fields are of particularly ample dimensions. Thus the boundary for functioning of the stamping magnet lies at 14 to 16 V and the figure magnets step forward without fault at 12 to 14 impulses/s at 16 V.

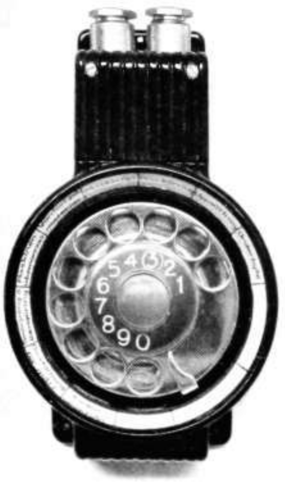


Fig. 6
Report transmitter KEE 9901

X 4288

Report transmitter

To transmit the impulses necessary for stamping the desired figure there is used the report transmitter KEE 9901, consisting of a dial mounted in a cast-iron case, on the flange of which there is space for labelling indicating what the figures reported mean, see Fig. 6. The dial, RGA 9901, differs from standard construction in that its contact spring assembly contains a break and a make-and-break in addition to the impulses springs and that its connection is quite special, but especially because it is provided with an indicator showing what figure was last dialled.

The connections between report transmitter, impulse transmitter and stamping unit are shown in their simplest form in Fig. 7. When the impulse transmitter contact is made the stamping magnet of the stamping unit receives a short current impulse through the electrolytic condenser *C* (this is inserted in the circuit to reduce current consumption should the impulse transmitter stop with the contact made) and each time this occurs a stroke is stamped in the diagram. When the dial is rotated the impulse transmitter is disconnected and the figure magnet is connected to the dial impulse spring. The figure magnet receives a number of impulses corresponding to the figure dialled and when that number has been transmitted the stamping magnet is in turn connected in, receiving an impulse by which the dialled figure is stamped. The dial in fact transmits one impulse more than indicated by the figure. Stroke stamping, *i. e.*, the recording of, say, a machine running, can thus proceed unaffected by reporting except for the brief moment required for dialling the figure.

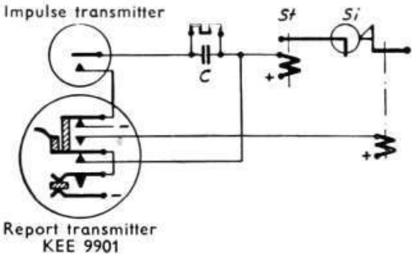


Fig. 7
Skeleton diagram of centralograph installation

X 4285

C electrolytic condenser
Si figure magnet
St stamping magnet

New Electric Fencing Apparatus

A GARTNÄS, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

U.D.C. 621.34:631.27

One of the difficulties in application of modern rational pasturing in agriculture has been to hit on a suitable fencing for dividing up pasture grounds and hill pastures into convenient pockets. A simple and effective solution of the problem has been provided by the electric fence and special electric fencing apparatus have been put on the market in recent years. L M Ericsson has contributed by a new effective design and this is described in the present article.

The fencing and its problems are without a doubt as ancient as livestock keeping and a multitude of different methods have been tried. The requirements are that the fencing shall be inexpensive, simple to construct, easy to move, particularly where the exhaustion of hill pastures is concerned, it should not injure or frighten the cattle, while at the same time it is effective in preventing the animals from breaking out and, as far as possible it should be so shaped that it does not clash with the scenery.

To arrive at a fencing which meets all these requirements the help of electricity has been called in, as it has been found that animals avoid coming into contact with wires under tension having connection with a source of current, such as is shown by Fig. 1. Occasionally, ingenious farmers have applied this method in the last decades but it was not applied to any great extent in Sweden until some five years ago. To make the electric fencing method harmless for both animals and persons, while still being effective, special electric fencing apparatus have been designed and put on the market, these transmitting high tension current impulses on a fencing wire, usually barbed wire, suspended on insulators at suitable height above the ground.

Principle

The electric fencing apparatus work generally on the principle shown by Fig. 2.

From a source of current there is led current through the primary winding of a transformer, whereupon an armature is attracted by the transformer's iron core, so that a contact in the circuit is broken. By this means there is induced a brief but high-tensioned current impulse in the transformer's secondary winding, one pole of which is connected with the fencing wire and the other with earth. By means of a pendulum the contact is again made and the process is repeated.

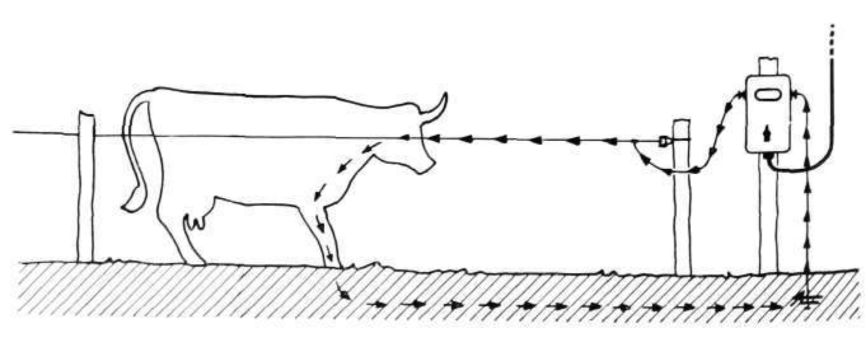


Fig. 1 X 5997
Principle of operation of electric fencing

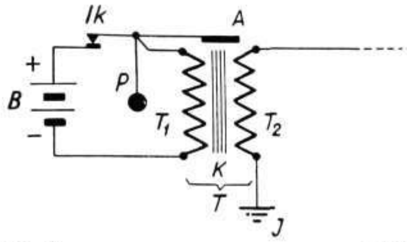


Fig. 2 X 4282

Diagram showing principle of electric fencing. Apparatus of usual construction.

A	armature
B	battery
Ik	impulse contact
J	earth
K	iron cores
P	pendulum
T	transformer
T_1	primary winding
T_2	secondary winding

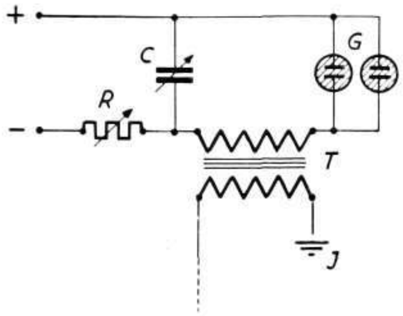


Fig. 3 X 4283

Skeleton diagram of L M Ericsson's electric fencing

C	condenser
G	glow tube
J	earth
R	resistance
T	transformer

To provide against accidents the electric fencing apparatus at present sold in Sweden must comply with certain government stipulations, in force since 1st July 1944. These stipulations prescribe that the tension of the current impulses must not exceed 5000 V, the impulse interval not be longer than 0.1 s, the frequency not be above 72 impulses/min in certain conditions of load and the current impulse not contain greater intensity of electricity than 2.5 mAs. These apply equally to mains connected apparatus and battery apparatus.

L M Ericsson's electric fencing apparatus differs from others on the Swedish market in that it has no contacts that may burn out or any movable parts that may wear. Fig. 3 shows the principle of L M Ericsson's electric fencing apparatus.

The condenser *C* is charged over the resistance *R*. When the condenser's tension has risen to a value corresponding to the glow tube lighting tension, the glow tube *G* lights, and then the condenser is discharged through the primary winding of the transformer *T*, until the condenser's tension has fallen to a value corresponding to the extinguishing tension of the glow tube, whereupon the glow tube breaks the current. The condenser is charged anew and the procedure is repeated. The power fed in is converted in the transformer to suitable and harmless tension and current values.

The advantage of this arrangement over that shown in Fig. 2, is above all to be found in the greater reliability of operation and the shorter impulse time. The shorter impulse time means that the intensity of the impulses can be made many times greater without exceeding the stipulated amount of electricity. The greater intensity means that the impulses will be particularly effective. It has consequently been found that there is no need to use barbed wire but that appropriate fencing effect is obtained with fence of not too great length even when plain fencing wire is employed. This means that the fencing will be extremely simple and inexpensive to put up, while at the same time it protects the animals against hurt.

Moreover the arrangement ensures that the intensity of the current shocks will be independent of the tension of the current source, a matter of considerable importance as the tensions of rural power and lighting systems vary considerably. The intensity of the current impulses can be simply and effectively adapted to different conditions, such as the length of the fencing, the dampness of the ground, the sensitiveness of different animals and so on, simply by increasing or decreasing the capacity of the condenser.

Construction

L M Ericsson's electric fencing apparatus are made both for connection to lighting mains and for battery operation.

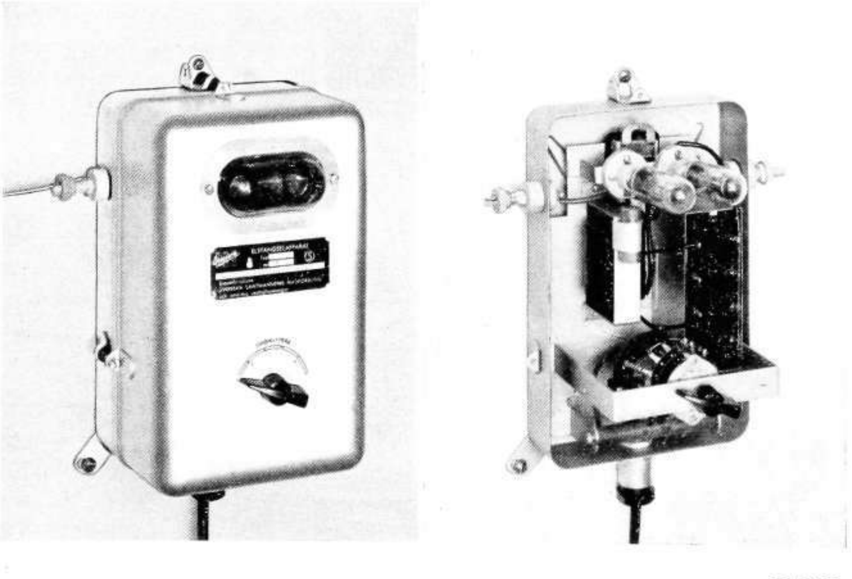


Fig. 4 X 5998

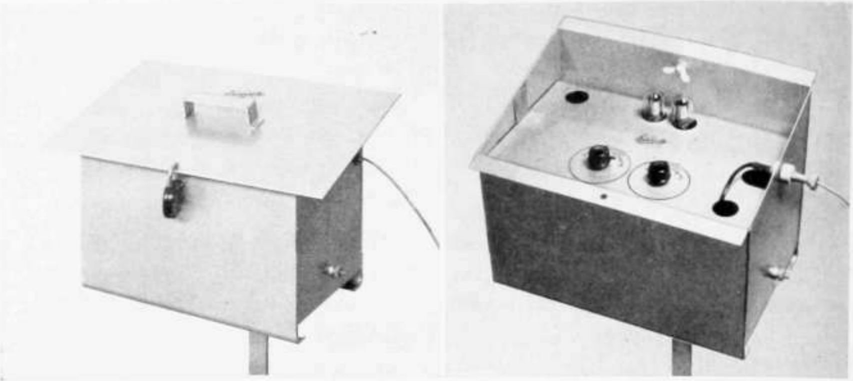
Electric fencing apparatus for mains connection

left, with and, right, without cover. Above, the two glow tubes, below them condenser and transformer

Fig. 5 X 5999

Electric fencing apparatus for battery operation

right, with cover removed so that glow tube and setting knob for impulse speed and current intensity are visible



There are two types of apparatus for mains connection: for 220 V and for 110—127 V mains tension. Both types will stand an over-tension of 20 %. The apparatus in the lower tension group are intended for A.C while the other tension group apparatus may be operated on both A.C and D.C.

The intensity of current shock may be regulated to suit the length of fence.

LM Ericsson's electric fencing apparatus are provided with two glow tubes coupled in parallel, only the lamp with lowest ignition voltage working. If this lamp is damaged the other comes automatically into operation. This occurs also if the ignition voltage on the working lamp increases so that it exceeds the voltage of the other lamp. The fact that the functioning glow lamp no longer lights does not therefore mean that it is incapable of working.

The mains-connected electric fencing apparatus is built into a case of bronze-aluminium painted sheet metal, see Fig. 4, with the dimensions: height 310 mm and width 230 mm. The weight is 3.5 kg.

The battery-operated electric fencing apparatus is built into a strong sheet-metal box that can be locked with an ordinary padlock, see Fig. 5. The box is opened by moving the cover to the side making the setting knob accessible. The battery-operated apparatus is provided with knob for adjusting the impulse speed, as this affects the life of the battery to a high degree.

The battery, which is located in the bottom of the box, is a 200 V dry battery, normally sufficient for about 5 months' continuous operation.

Dimensions of the apparatus box are: length 425 mm and width 260 mm. Without battery the weight is 6.5 kg and with battery 12.5 kg.

Insulators

To facilitate the building of the electric fencing itself, LM Ericsson has worked out a number of special accessories: bushings, line connection clamps, splicing clamps and also a special electric fencing insulator that can be attached without tools, screws or nails.

This self-attaching insulator is mainly intended for electric fencing that requires frequent moving. The insulator can be fixed or detached in a few seconds from the poles and the wire is fixed to the insulator without bending.

The insulator consists of an insulator holder, insulator and wire holder. It is attached to the poles by means of a spring and a chain. The links of the chains are of such dimensions that the chain link can be adapted to the pole diameter, which may be between 30 and 100 mm.

As neither nails nor screws are required for attaching, the pole material is not injured. This saving of material by the electric fencing insulators is of particular importance as the material of pens and hay-driers is often used for movable fences and this material when undamaged can later be used for the harvest.

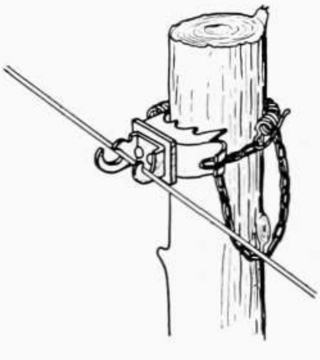


Fig. 6 X 4284

Self-attaching electric fencing insulator

Connection of Sprinkler Installations to Fire Telegraph Networks

G BERGH, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

U.D.C. 654.924.5

Both on the part of industrial establishments and of the fire brigades interest has long been directed to extended connection of sprinkler installations to the fire telegraph network for signalling direct to the fire station. As up to now it has been necessary to employ the same central equipment for the purpose as for automatic fire alarm installations, the connection has proved to be comparatively costly. L M Ericsson has now designed a special central apparatus which enables such connection to be made at appreciably lower cost than formerly.

The description of the new central apparatus given below is reproduced with kind permission from »Brandskydd» (»Fire Protection») No 1, 1941.

In conformity with the prescriptions drawn up by the insurance companies for sprinkler installations, these must always include a turbine bell which is connected with the main valve of the installation by special piping. When a sprinkler comes into operation water is forced into the piping, actuating a turbine wheel which sets the bell in function. By means of this bell's ringing the staff are called to take action after the fire is extinguished by shutting off the water supply and where necessary assist in the work of extinguishing.

Nevertheless, as one cannot always count on the signal from the turbine bell being heard or that those who hear the signal know what it means, being therefore not in a position to take measures, it has always been desirable that the sprinkler installation should be connected to the fire brigade. The new apparatus made by LM Ericsson ensures entirely effective connection, even though from the viewpoint of security it does not meet and hardly needs to fulfil such extremely high demands as are required for connection of automatic fire alarm installations.

The central apparatus, Fig. 1, consists of a frame of polished stained oak, fitted with a door on the front, behind which a signal mechanism with press-button operation is mounted. Inside the door is the signal mechanism, a telephone instrument for communication with the fire station, a voltmeter with press button for control of battery, a press button for testing the sprinkler

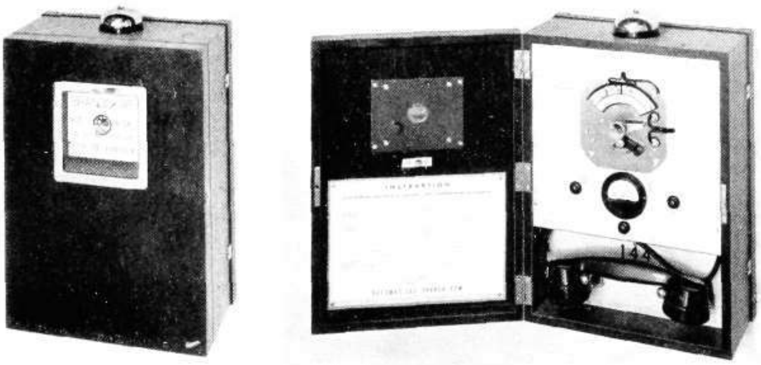


Fig. 1 X 6205

Central apparatus

left, front with door shut, right, with door open: above, signal mechanism and telephone device, below voltmeter with test press buttons, at the bottom, telephone handset

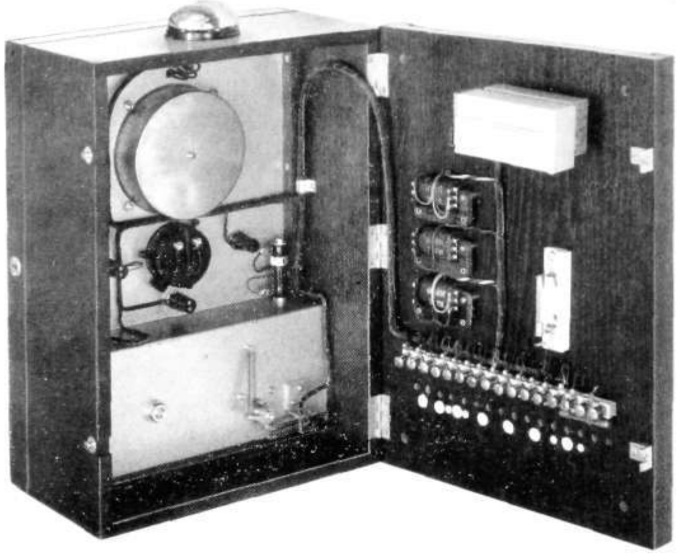


Fig. 2 X 5746

Central apparatus

with back open; on the back-piece, relays and terminal clamps are mounted

installation connected and a press button for restoring after alarm has been given. On the back-piece of the frame, Fig. 2, there are mounted relays and terminal clamps for connection of battery, fire-alarm box circuit, local alarm installation, earth and an extra bell; this last is connected in parallel with a bell mounted on the frame of the central apparatus.

The installation is driven from a 12 or 24 V battery, dry cells being suitable. For this reason a load resistance has been inserted parallel with the voltmeter for voltage test, so that normal deflection of the voltmeter is obtained only in case the battery capacity is sufficient for emitting the alarm signal.

The installation operates on the working current principle. On alarm from a contact device in the sprinkler system connected to the central apparatus the circuit is closed to the relay in the fire-alarm box. The relay is held over its own contact and the restoring press button and in turn closes a circuit to the signal mechanism operating magnet, whereby the signal mechanism is released. When that is released the control contact in the signal mechanism is broken. At the same time there is closed over the relay's contacts a circuit to the signal bell and the extra bells that may be connected to the plant. The bells continue to ring until the fire-alarm box door is opened and the restoring button is pressed. The door is fitted with a lock device that then prevents the door from being closed until the signal mechanism has again been wound up.

To enable the sprinkler installation connected to be effectively tested, the line from the sprinkler contact should be drawn in loop. On pressing the test button, current is obtained to the relay over the line loop, so that both loop and fire-alarm box are tested.

It is possible to connect to a central apparatus of this type also hotel fire-alarm plants. These as a rule are made as purely local installations without any connection to the fire telegraph network. Nevertheless, the new central allows of such connection that a local alarm signal is automatically transmitted to the fire brigade.

The telephone instrument mounted in the central apparatus is mainly intended for use when testing the plant. At the same time it provides facility also of obtaining direct communication with the fire station, or possibly the police station in the event the fire telegraph network is made as combined fire and police alarm installation.

Fire-Alarm Pillar Boxes

SÅ NILSSON, LM ERICSSONS FÖRSÄLJNINGSAKTIEBOLAG, STOCKHOLM

U.D.C. 654.147.4

In present day town planning there is a tendency to increase the total width of a road by setting back the buildings from the pavement and providing a small garden space in between. This is particularly the case in suburbs of garden city type.

In such cases the fire alarm boxes cannot be mounted on the house walls as they would be too inaccessible and not sufficiently noticeable. The boxes have, therefore, been fitted on lamp posts, telegraph poles or special poles of wood or steel. The indicating lamps are then fitted on the same poles above the alarm box and the junction boxes with fuses immediately underneath the latter.

These installations have, however, been lacking in uniformity and it has been suggested in many quarters that LM Ericsson should develope a self-contained fire-alarm box. A pillar box design has now been completed to meet this demand.

The pillar fire-alarm box, Fig. 2, contains the same equipment and operates in the same manner as the police fire-alarm box of standard type: signal mechanism with draw-out handle behind glass pane, telephone handset inside the door with sealed handle. The door can either be opened by the public using the handle, after breaking the seal, or by police and firemen with key without necessity of breaking the seal. In addition the box contains lighting arrester and possibly police flash light relay together with distribution boxes for the fire-alarm box lines and the fire-alarm box lighting with their fuses. The lighting is assembled with the box.

As the pillar box will usually be set up on footpaths all sharp corners and projecting parts have been avoided in order to prevent accidents to persons knocking into or being knocked into the box. It is constructed in the form of a cylindrical pillar, about 40 cm in diameter and 170 cm high. It is intended for mounting on a concrete foundation cast into the ground, with a height above the ground of some 30 cm. The total height will then be 200 cm, so that the draw-out handle will be at standard level, 150 cm above the ground.

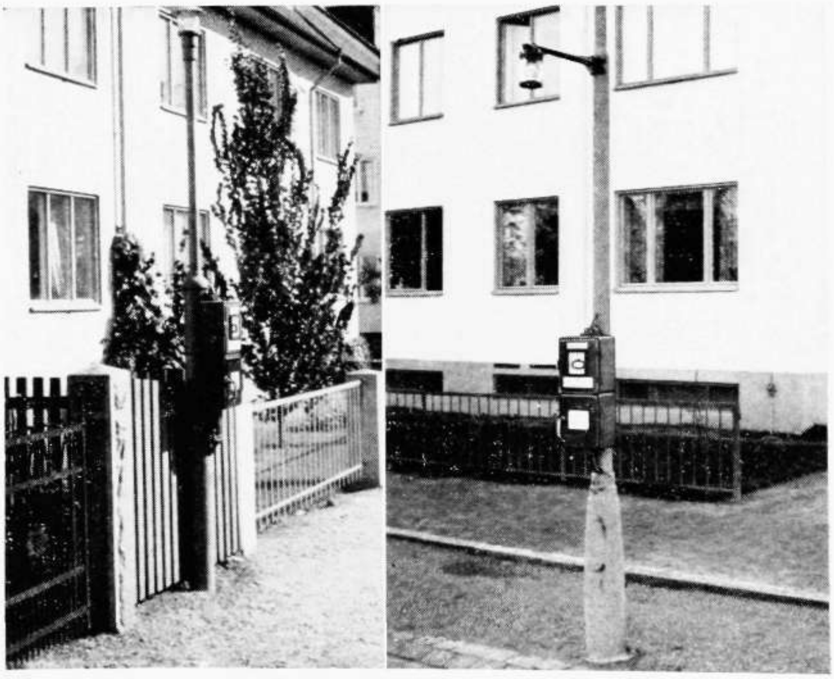


Fig. 1 X 5892
Police fire-alarm boxes mounted on poles

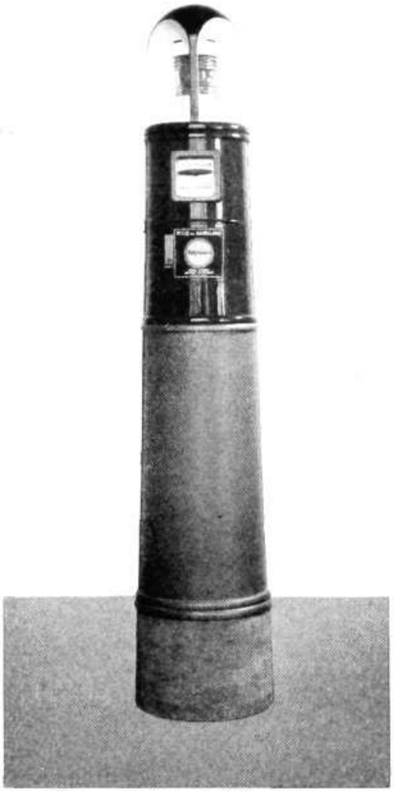


Fig. 2 X 4192
Fire-alarm pillar box

The bottom of the box consists of a circular cast-iron plate with holes for screw-threaded iron poles cast into the concrete foundation, by means of which the box is attached to the foundation. An iron frame is fixed to the bottom plate, this carrying two cast-iron plates, one at the top forming the box roof and one in the middle dividing the box into two compartments. Two fixing plates are screwed to the sides of the iron frame, one in the upper half and one in the lower half of the box. These plates ensure stability and are also used for mounting components comprised in the box, in the upper part fire-alarm box components, in the lower part distribution and fuse boxes. The boxes for the fire-alarm box and for the lighting are separated by the mounting plate. The outer casing consists of two cleft sheet metal cylinders, one above and one below. They are hinged on to one side of the iron frame. At the other side they can be fastened by a special lock device which drags the cylinder over the upper and middle or middle and lower cast iron plate respectively, so that very good tight fit is ensured. By this arrangement all parts in the box are very easily accessible, see Fig. 3.

In the upper part of the box a door is inserted for the telephone handset, the handle of which is set in the door. When the door is opened a lamp lights, illuminating the handset. On the top of the box there is a cast iron hood fitted with a lantern lens. The hood is so shaped that the beam from the lamp inside the lens is reflected against the edges of the opening, thus augmenting the light effect. The light is used both for marking the position of the box at night and for calling patrolling policemen by flash signals.

In the lower part of the fire-alarm box there is large space available which may be used for purposes connected with accidents or air-raid precautions. Here might be placed a first-aid box, tools suitable for use in street accidents or bomb hits. Shut-off cocks for water and gas might be put in the box together with a plan showing where shutting-off can be done.

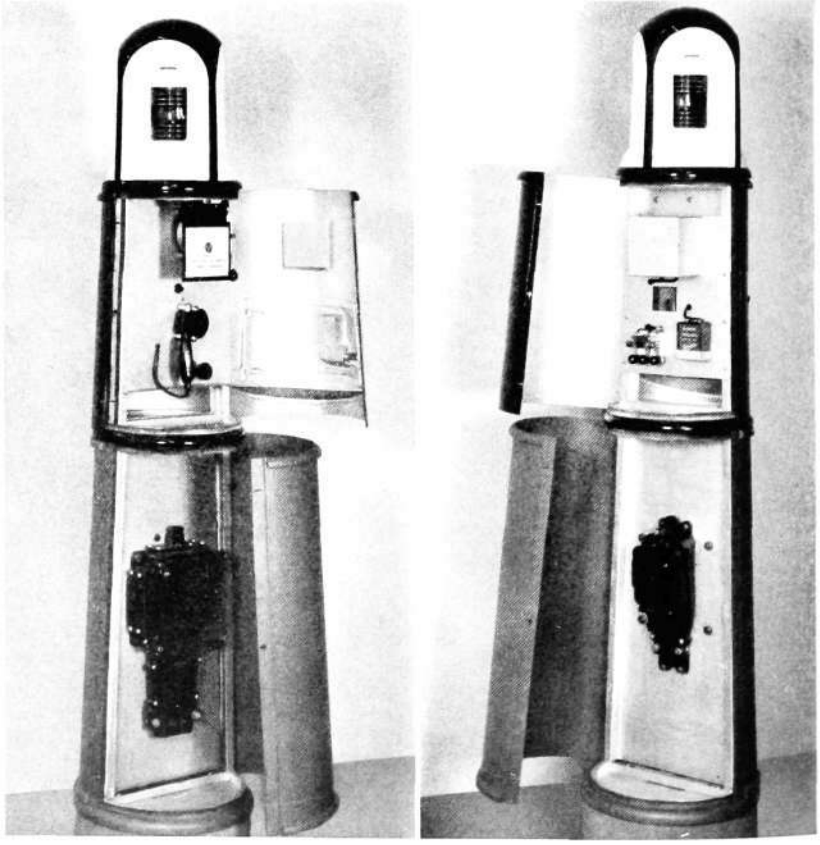


Fig. 3 X 5891
Fire-alarm pillar box
left, with front doors opened and signal mechanism, telephone handset and distribution box visible; right, inside the door of the back, the fire-alarm box components and fuse box

Automatic Staff Locator

E LINDGREN, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

U.D.C. 654.938

In offices, factories etc. some members of the staff have more or less ambulating work and are difficult to contact. To enable such persons to be easily and quickly found various kinds of staff locator systems have been devised. In most systems persons are generally called by means of lamp boards fitted in rooms and corridors. These boards consist of a number of lamps in different colours operated from a central set, preferably at the company's telephone switchboard. Each person is allotted a certain lamp combination and when this combination is indicated on the lamp boards he knows that he is wanted; he will then contact the telephone operator or the person in charge of the central set. This set is provided with a switch for each coloured lamp.

When locating a person it is thus necessary first to find his lamp combination and then to operate the corresponding switches. If in the process of finding one person someone else has to be located, the switches in the first combination must be restored before the other combination is operated. These manipulations are rather lengthy and tedious for the telephone operator, who is often very busy. L M Ericsson have therefore developed a new lamp locator system appreciably simpler in operation.

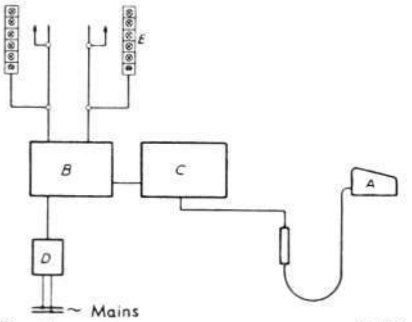


Fig. 1 X 4179

Skeleton circuit of staff locator installation

- A operating device
- B relay set (operating relays)
- C relay set (queuing device)
- D transformer
- E lamp board

Construction

A staff locator plant, see Fig. 1, consists of an operating device, two relay sets, together with lamp boards and buzzers. With A.C. mains the plant can conveniently be connected over a transformer, otherwise a 24 V or 48 V battery should be used.

The standard operating device, Fig. 2, is a table set but may also be made for wall mounting, if desired. It contains 30 press-buttons, together with pilot lamps, button *Sö* for automatic location, button *Fl* for fixed light on the boards and button *Su* for manual buzzer signals. Finish dark green enamel. Dimensions 210 × 130 × 115 mm.

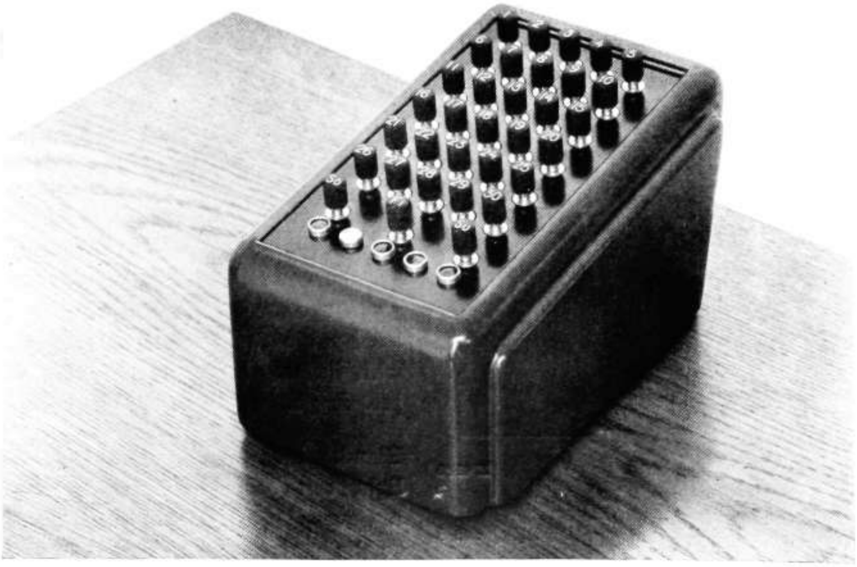


Fig. 2 X 5872

Operating device for staff locator

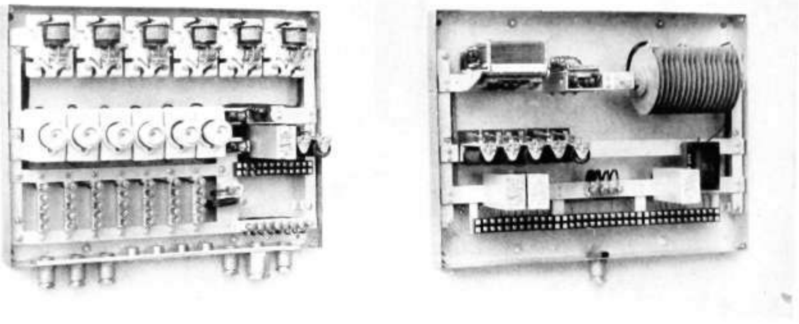


Fig. 3 and 4 X 7263

Relay sets for staff locator

covers removed. Left hand figure, top row six mercury relays, second row fuses and impulsing relays, for flash signals, bottom row terminals. Right hand figure, top row ball selector setting lamp combination, with cam relay and rectifier unit to the right, second row, operating relays for selector and cam relay, bottom row condensers and terminals.

The relay set, Fig. 3, contains six mercury relays, five operating the lamps in the boards and one the buzzers, along with two impulsing relays transmitting flash impulses to the mercury relays. In addition there are fuses and terminals.

The relay set, Fig. 4, comprises a ball selector, a cam-relay with its operating relays and rectifier for connection to A.C. mains. The relay sets are mounted in aluminium-sprayed mild steel covers for wall mounting. Dimensions 500 × 375 × 190 mm.

There are two types of lamp-boards, a large one of sheet-metal and a smaller one in bakelite, Fig. 5, the former being designed for large rooms and corridors and the small short range board for offices and other small rooms. The boards are fitted with clear lamps behind coloured cellon windows.

Functioning

To call a person the appropriate button in the operating device is pressed. This marks a position on the selector in the queuing device. The selector starts and finds this position, remaining there. The mercury relays for the required lamp combination are operated over contacts in the selector. At the same time the cam-relay starts sending out short signals on the buzzers with regular intervals.

If more than one person is to be called the corresponding buttons are pressed in the operating device and in addition the queuing device is set to automatic call by pressing button *Sö*. The selector then finds the nearest marked position and the corresponding lamp combination is issued on the boards. The cam-relay starts and after a time, adjustable between 10 and 60 s, the selector continues to the next marked position; the lamp combination corresponding to this position is indicated on the lamp boards.

Lamp combinations are thus issued on the boards at even intervals. When the selector has passed all marked positions it repeats the procedure, as long as the button *Sö* for automatic call remains operated. Each time the lamp combination changes a short buzzer signal is sounded to draw attention to the new combination. The buzzers can also be manually operated by pressing button *Su*.

In installations for less than 30 persons flash signals are used for all lamp combinations; installations for 30 to 60 persons have flash signals for 30 combinations and fixed light for the remainder. In the latter case each button will serve two persons, the operating device containing only 30 buttons. Those having the same colour combination are differentiated by one being called with flashing light and the other with fixed light. Fixed light is obtained by pressing button *Fl* in the operating device.

Simultaneous calls of several persons in a plant with both fixed and flashing light can only proceed with one kind of signal at the time. Priority may, however, be given to a small group, which can be called with flash signals at the same time as fixed light calls.

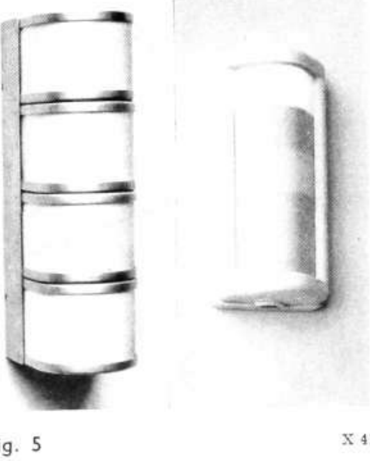


Fig. 5 X 4180

Lamp-boards

left, with 4 lamps, in sheet metal; right, with 5 lamps, in bakelite

U.D.C. 621.395.343

LINDSTRÖM, E: *Automatic Telephone Exchange on the L M Ericsson System at Istanbul.* Ericsson Rev. *23* (1946) No 2a pp. 176—186

A new exchange for 2000 subscribers on the LM Ercsson system with 500-line selectors has been put into service at Şişli in Istanbul. The exchange works in direct conjunction with automatic exchanges in other sections of the city, built earlier on the Western Electric's Rotary system. This joint traffic is operated in the same manner as traffic between the older exchanges and the registers of the one system directly operate the selectors of the other, which has been made possible by adapting the new exchange to the grouping of the Rotary system. Nevertheless, it has been possible for the most part to utilize LM Ericsson's normal mechanical designs without modification.

U.D.C. 621.395.343

BJUREL, B: *New Swedish Telephone Plants with 500-line Selectors.* Ericsson Rev. *23* (1946) No 2a pp. 187—197

For the automatisation of large and medium-sized Swedish telephone plants a new type of telephone exchange with 500-line selectors has been developed. This type of exchange, taken into service for the first time on the automatisation in 1943 of the Eskilstuna telephone exchange, displays several innovations in the technical equipment. Among other things it may be mentioned that the equipment for inter-district traffic has been redesigned and that the setting up in the exchange itself of trunk calls has been automatised.

U.D.C. 621.395.343

LINDSTRÖM, E: *Automatisation of the Åbo Telephone Network.* Ericsson Rev. *23* (1946) No 2a pp. 198—203

The Åbo Telephone Association which handles the telephone service of Åbo and neighbourhood, commissioned Telefonaktiebolaget LM Ericsson in July 1938 to deliver and erect an automatic telephone exchange for the town of Åbo and a manual toll exchange for joint working with adjoining toll exchanges. The plant, according to contract, was to be handed over in working before the close of 1940, but owing to internal developments in Finland the work was considerably delayed. The handing over, which took place on the 4th July, 1942, coincided with the Åbo Telephone Association's 50 year jubilee.

U.D.C. 621.395.353

LUNDKVIST, K: *Semi-Automatic Rural Exchanges.* Ericsson Rev. *23* (1946) No 2a pp. 204—210

The LM Ericsson semi-automatic rural exchanges are intended to replace small switchboards of L. B. type and combine the operation for a number of small L. B. exchanges to a common operating place. The system compared with a manual L. B. system involves no alteration of the traffic capacity, number of lines or demands on the construction or insulation of the subscriber network. The telephone instruments are normal L. B. magneto instruments and are operated in the ordinary manner.

U.D.C. 621.395.663.6
654.151.4.034.5

Bergholm, E: *Coin Boxes in Telephone Service.* Ericsson Rev. *23* (1946) No 2a pp. 211—217

With the introduction of coin box instruments into a telephone area, the technicians concerned are frequently faced with problems and questions that to some extent are outside those normally encountered in tele-technics proper. The varying circumstances regarding coinage and rates in different countries combined with the dissimilar technical conditions at various places call for individual adaptation to local conditions for each separate locality.

U.D.C. 621.395.663.6

Bergholm, E: *New Coin Boxes.* Ericsson Rev. *23* (1946) No 2a pp. 218—220

The object of the article is to indicate in the light of historical developments the possibilities and limitations existing at the present time in this sphere. Some new fields of employment for these instruments are described. Rational manifacture demands uniformity in production and the making of large quantities in series. These demands could hitherto only be satisfied to a limited extent in the manufacture of coin box instruments owing to the variation of coins in the different countries. In the article is described a coin box instrument in which only one feature the coin slot, requires individual manufacture for each kind of coin.

U.D.C. 621.395.262

Ericsson, E A: *Hallway Switchboard with XY-Selectors.* Ericsson Rev. *23* (1946) No 2a pp. 221—222

For ordinary blocks or flats which do not generally contain more than thirty to forty appartments, the hallway telephone described in Ericsson Review No 4, 1934, has found wide employment. In recent years, however, buildings comprising up to several hundred flats have been erected and for these LM Ericsson has designed a hallway switchboard with XY-selectors forming the connecting device.

U.D.C. 654.147.2

Nilsson, S Å: *Telecommunications in the New Fire-Station at Brännkyrka, Stockholm.* Ericsson Rev. *23* (1946) No 2a pp. 223—229

In an inquiry from Stockholm Fire Service for an alarm telegraph installation at the new Brännkyrka fire-station, the specification called for a mobile central equipment. At the time of this inquiry LM Ericsson's standard equipment consisted of marble instrument panels mounted on walls or on the front of large cabinets, the telephone and telegraph equipment being fitted on separate desk in front of the panels. As such a plant did not need the specification in question and partly also to modernize the exterior, it was decided to redesign the constructional lay-out completely. This new design will in future be used as standard and a more detailed description is given in the article.

U.D.C. 654.915.2-8

Ahlberg, C: *L M Ericsson's Remote Indicator System for D.*
Ericsson Rev. *23* (1946) No 2a pp. 230—233

The demand for remote indicators has long existed and many syste are to be found on the market. LM Ericssons has worked out a D. operated remote indicator system which can be employed for locator an order-giving plants as also for marking and reporting plants. The lin used for this system are three-wire and of the same dimensions as f ordinary telephone lines.

U.D.C. 654.937

Hedén, A: *Dial Operated Centralographs.* Ericsson Rev. *23* (194
No 2a pp. 234—237

The centralograph is to-day finding more and more uses in industry, bei a valuable and sometimes indispensable means of increasing efficien and supervising the continuity of processes. In order to cover the ne demands which have arisen through this wider use, a new centralogra has been developed which, with several improvements in the princip design and a more modern exterior, contains some essentially new feature

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U.D.C. 621.34:631.

Gartnäs, A: *New Electric Fencing Apparatus.* Ericsson Rev.
(1946) No 2a pp. 238—240

One of the difficulties in application of modern rational pasturing in agr culture has been to hit on a suitable fencing for dividing up pastu grounds and hill pastures into convenient pockets. A simple and effecti solution of the problem has been provided by the electric fence and speci electric fencing apparatus have been put on the market in recent year LM Ericsson has contributed by a new effective design and this is describ in the article.

U.D.C. 654.924

Bergh, G: *Connection of Sprinkler Installations to Fire Telegra*
Networks. Ericsson Rev. *23* (1946) No 2a pp. 241—242

Both on the part of industrial establishments of the fire brigades intere has long been directed to extended connection of sprinkler installations the fire telegraph network for signalling direct to the fire station. As to now it has been necessary to employ the same central equipment f the purpose as for automatic fire alarm installations, LM Ericsson h now designed a special central apparatus which enables such connecti to be made at appreciably lower cost than formerly. The description the new central apparatus is reproduced with kind permission fro »Brandskydd» (»Fire Protection») No 1, 1941.

U.D.C. 654.147.4

Nilsson, S A: *Fire-Alarm Pillar Boxes.* Ericsson Rev. *23* (1946)
No 2a pp. 243—244

In present day town planning there is a tendency to increase the total width of a road by setting back the buildings from the pavement and providing a small garden space in between. This is particularly the case in suburbs of garden city type. In such cases the fire alarm boxes cannot be mounted on the house walls as they would be too inaccessible and not sufficiently noticeable. The boxes have, therefore, been fitted on lamp posts or special poles of wood or steel. The indicating lamps are then fitted on the same poles above the alarm box and the junction boxes with fuses immediately underneath the latter. These installations have, however, been lacking in uniformity and it has been suggested in many quarters that LM Ericsson should develope a self-contained fire-alarm box. A pillar box design has now been completed to meet this demand.

U.D.C. 654.938

Lindgren, E: *Automatic Staff Locator.* Ericsson Rev. *23* (1946)
No 2a pp. 245—246

In offices, factories etc. some members of the staff have more or less ambulating work and are difficult to contact. To enable such persons to be easily and quickly found various kinds of staff locator systems have been devised. In most systems persons are generally called by means of lamp boards fitted in rooms and corridors, but these systems have been rather lengthy and tedious for the telephone operators. LM Ericsson have therefore developed a new lamp locator system appreciably simpler in operation. The system is described in the article.

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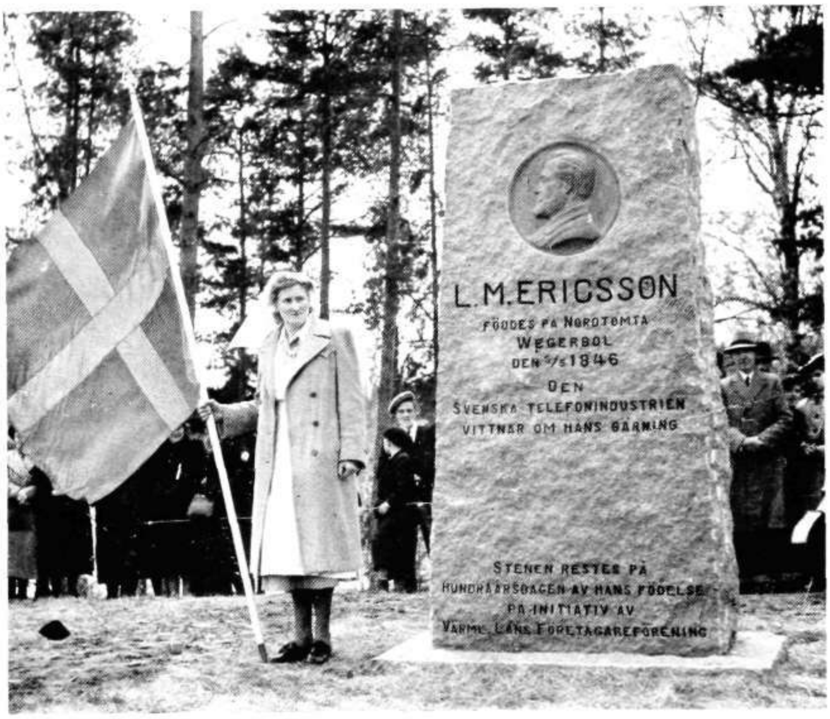
To Commemorate the Centenary of Lars Magnus Ericsson's Birth

1846 — May 5 — 1946



Memorial stone to Lars Magnus Ericsson set up at Värmskog Church on the centenary of his birth

The 5th of May this year marked the hundredth anniversary of Lars Magnus Ericsson's birth. The centenary was celebrated both at Botkyrka churchyard in Södermanland where his remains rest and in his native parish of Värmskog in Värmland, where a memorial stone was unveiled not far from the farmstead where he was born.

To commemorate its founder the firm of Telefonaktiebolaget LM Ericsson has made donations amounting to half a million kronor. These include a foundation for the promotion of electro-technical research with a capital of 250000 kronor. Its object is to grant stipendiums to engineers and students at Sweden's technical colleges who are desirous of carrying on scientific research at home or abroad in the domain of electro-technics that is of special interest for the activities associated with LM Ericsson.

Stipendiums for 1946 have been awarded to Engineer Torkel Wallmark for carrying on at the Royal Technical University supplementary research in the domain of electronics and to the licentiates of technology Björn Nilsson and Hans Werthén to enable them to study television and transmission in the domain of ultra high frequency in USA and Britain.

*

New Series of Manual L. B. Switchboards with Cords

ERIK I ENGQVIST, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

U.D.C. 621.395.33

The work of development that is constantly going on even in respect of manual telephone exchanges has now resulted in LM Ericsson's new series of extensible L. B. cord switchboards, differing rather considerably from those hitherto produced. By the introduction of brighter colours and softer lines, for instance, the character of the new switchboards as pieces of furniture has been brought out to a greater degree than was formerly the case. Moreover, as regards the component parts a distinct departure in respect of choice of material and methods of manufacture has taken place in the direction of modern moulding materials and die-casting practice. Lastly, the assembling into units of components organically associated has been still further developed. In this way there have been produced switchboards that are aesthetically attractive, durable, simple to operate and easy to extend.

The new series of LM Ericsson's L. B. cord switchboards comprises the following types of single position telephone switchboards:

wall switchboards for up to 50 lines,
floor switchboards » » » 100 »
» » » » » 200 »

For multi-position telephone switchboards with up to 800 lines there will in addition be set up:
multiple switchboards, 1-position, 2-panel,
multiple annex, combined with cable-turning section.

The whole of the new series may be said to be based on fairly extensive new designing work in respect of the component parts, especially the calling and connecting devices.

When this work of designing was started the goal set was the attainment of certain minimum requirements, which may be summarised as follows:

1) The calling and connecting devices of the lines to be assembled in units of 10 devices.
2) The equipment for a cord circuit to be assembled in a compact and easily manipulated unit.
3) All visual signals to be flush mounted but distinct and their restoration to be combined with other necessary operations.
4) The life of the cords to be lengthened by the introduction of plugs with protective spirals and if possible lighter pulleys.
5) Brighter surface finish of all woodwork to be introduced and particular attention devoted to form.
6) The advantages of bakelite to be taken into consideration for non-metallic parts requiring good insulation, hard-wearing surface or a complicated shape.
7) The complete switchboards, out of consideration for freight and customs charges, should be of small volume and light in weight.
8) The switchboards should be easy to erect and easy to extend.

In their present state the new series of L. B. switchboards very well fulfil the demands imposed.

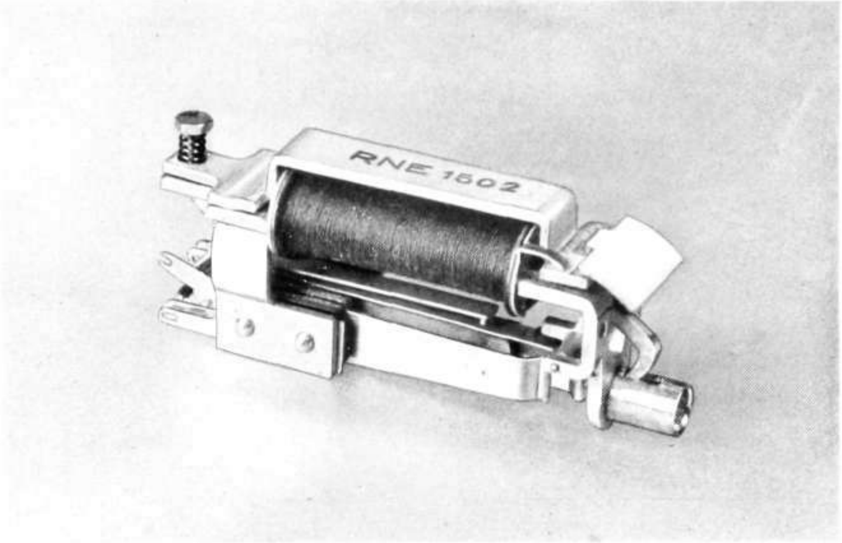


Fig. 1 X 6215
Drop-indicator jack type RNE 15

Components

The device that mainly sets its mark on the new L. B.-switchboards is undoubtedly the new drop indicator such as is used both as calling device on the lines or as clearing signal device on the cord circuit. The calling and connecting device for the lines has been made as a drop-indicator jack. Fig. 1 shows the new drop-indicator jack, which has been given the designation *RNE 15*. It comprises two main parts: the calling indicator and the connecting jack.

The calling indicator magnetic field is the same in principle as earlier drop indicators. The winding space, however, has been diminished by about 25 %, thus making the whole indicator shorter. At the rear end the armature is pivoted on two guide pins and the width of stroke is determined by a lug bent out from the supporting flange of the coil frame.

The sensitivity is regulated by adjusting screw and spring in the rear of the indicator. The shutter itself has been given a form that allows it to lie flush and protected when the jack is fitted in its strip. In home position the shutter hangs on a hook formed on the front edge of the armature, while at the same time it keeps the alarm contact open. When the armature is attracted

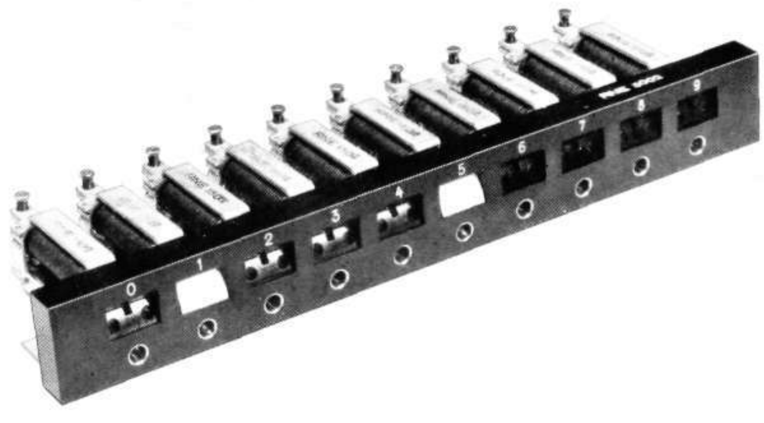


Fig. 2 X 6213
Drop-indicator jack assembly type RNE 50

the shutter is released and falls by its own weight, on which the alarm contact is made. Restoration is done automatically when a plug is inserted in the jack. The calling indicator is normally wound with 0.10 TE, giving app. 7000 turns and 500 ohm. It works reliably for a delivered power of app. 0.04 W.

The connecting jack is built up in the usual manner with insulation inset of pure bakelite. The alarm contact is built on to the jack and has had its soldering tags so shaped that bare-wire connection between adjoining indicator jacks is possible. The connecting jack is attached to the indicator by a single screw. The jack is only made for 5.76 × 23.8 mm plug, which is our present standard.

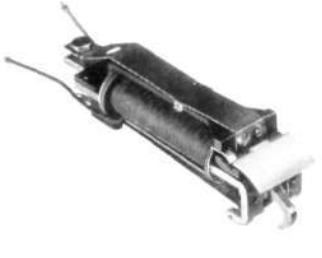


Fig. 3 X 4446
Clearing indicator type RNA 17

A special strip has been designed for the mounting of the indicators jacks. It is moulded of bakelite and holds 10 jacks. For each indicator jack there is a circular hole for the jack sleeve and a rectangular opening for the shutter. The indicator jack is fixed in the strip by two screws. The 10 calling devices in a strip are always numbered from *0* to *9*. The figures are engraved and filled up with white.

Fig. *2* shows the complete indicator jack assembly, which has been given the designation *RNE 50*. The dimensions of the front piece are: length 281.5 mm, height 36 mm, depth 80 mm. The assembly is therefore 12 mm lower than the old one. The weight of the complete indicator jack assembly is 830 g and a single indicator jack weighs 70 g, *i. e.*, half the weight of the old one.

The clearing indicator, with designation *RNA 17*, is built up in principle like the calling indicator for the indicator jack. There has had to be arranged, however, a special alarm contact which, in view of the indicator's vertical position in the cord pair strip must also serve as tension spring for the shutter, which of course cannot in this case fall by its own weight. Moreover the armature has been so shaped that it prevents the release of the shutter by jars or knocks. Fig. 3 shows the appearance of the clearing indicator.

The key, Fig. 4, is of our normal execution type *RMA 10*. An innovation is that the frame is now die-cast in zinc thus producing a more rigid frame with greater precision of construction than formerly. The pivoting of the lever arm has also been improved and as regards the switch handle plastic material has been adopted.

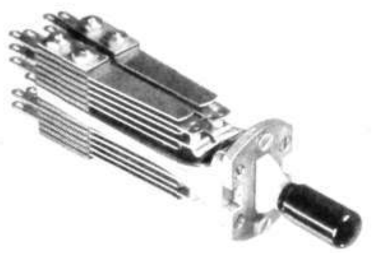


Fig. 4 X 4447
Key type RMA 10

The plug and cord, Fig. 5, have also been re-designed. The chief change in appearance consists in the addition of protective spiral. The shape and size of the plug itself have been retained, but the method of manufacture has been changed, moulding now being employed. A new method has been applied for the attachment of the cord to the plug, no screw being now required. The new plug, which has been given the number *RPR 3526*, is always made three-pole. Despite the addition of the protective spiral, the length is no more than 90 mm and the diameter app. 10.5 mm.

The equipment for a cord circuit has been combined in one unit, called the cord circuit strip, Fig. 6. The frame of the cord circuit strip is moulded of bakelite and space is provided for the following devices, counting from the front:

1 clearing indicator
1 speaking and ringing key
1 lamp (not shown on Fig. 6)
2 plugs
2 cord clip terminals.

The clearing indicator has been furnished with an iron sheath to prevent cross-talk. A mechanical coupling has been arranged between shutter and key enabling restoration of the shutter by means of the key.

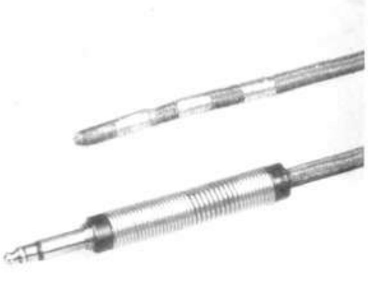


Fig. 5 X 4448
Cord (above) and plug RPR 3526

The cord circuit strip *RNN 10* has the following dimensions: length 185 mm, width 25 mm, depth 85 mm. The weight of a complete unit is app. 300 g.

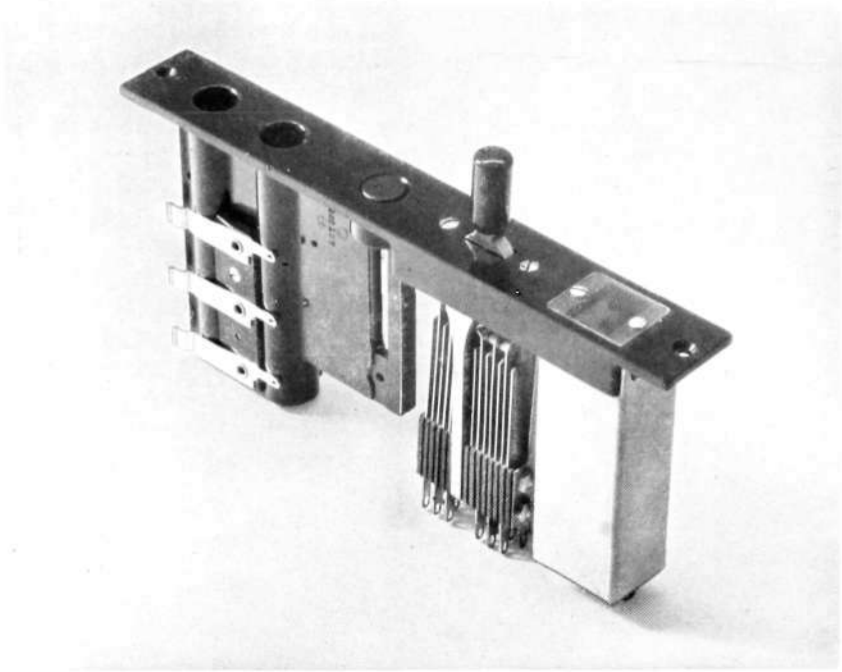


Fig. 6 X 6216
Cord circuit strip type RNN 10

Wall switchboard

The smallest size single position telephone switchboard, see Fig. 7, is normally made for mounting on a wall. It has a capacity of 50 lines and 10 cord pairs. The switchboard is of light oak and all corners and edges are rounded. The front is dominated by a vertical panel for the line units and the position set, together with a projecting inclined table for the switching sets. The back consists of a hinged door, strengthened to meet the stresses when suspending the switchboard on the wall. In exceptional cases where local conditions do not permit of hanging on the wall the switchboard may be placed on a special stand, see Fig. 8.

The 10-line unit, Fig. 9, comprises a completely wired unit for the calling devices of ten lines. It consists of an indicator jack assembly *RNE 5001*, a terminal block *NEM 1001* with screw terminals and a connecting cable. All the 10-line units in the wall switchboard are alike, both in respect of the numbering of the jacks and of the form of cable.

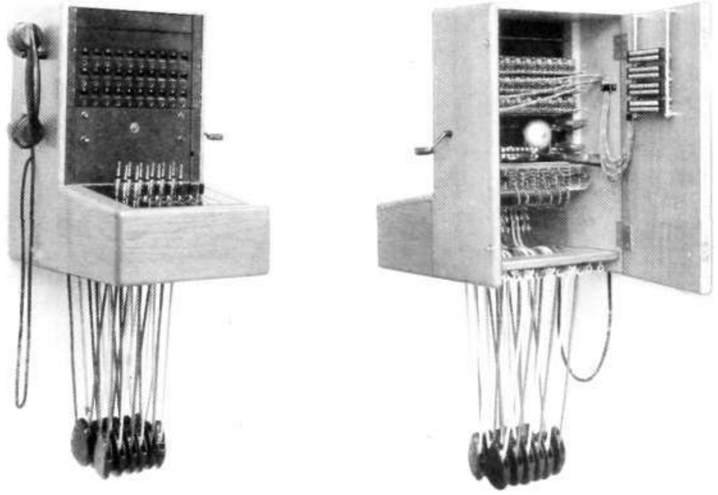


Fig. 7 X 6211
Wall switchboard ABH 1605
for 50 lines and 10 cord circuits; left, with back open

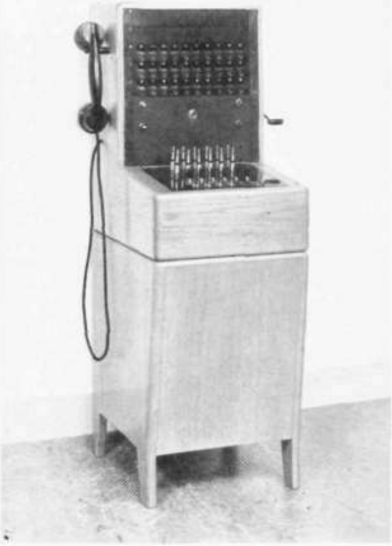


Fig. 8 X 4444
Wall switchboard ABH 1605
on stand

The switching set, Fig. 10, contains the fixed parts of a cord circuit. It consists of a cord circuit strip *RNN 1001*, containing clearing indicator, key and cord clip terminals, together with a connecting cable terminating in a 20-pole plug. Corresponding 20-pole jacks are located on the position set. Connecting up of a switching set can therefore be done by simple plugging, without the employment of soldering irons.

The position set, Fig. 11, consists of a wood panel covered with paper bakelite, on which all components common to the switchboard are fitted. On it will be found the hand generator and the night bell, the keys for connecting in the pole-changer and the bell, the keys for ringing on and insulating the answering cord, together with terminal block for the handset and dial if any. In addition the position set contains the above-named 20-pole jacks, which may be said to comprise the assembly bars for the switching sets. Connections to batteries, pole changer and additional bell are drawn to a separate terminal block. The operator's telephone is an ordinary handset with key, attached to the switchboard.

The terminal strips for 10-line units and position set are located on the rear door of the wall switchboard, which also provides good space for incoming cables.

The new wall switchboard has been given the designation *ABH 1605*. The dimensions are:

height 490 mm (with cords and pulleys 870 mm)
width 335 mm (excl. crank and handset)
depth 415 mm.

The net weight of a fully assembled switchboard is app. 25 kg.

The floor stand for the wall switchboard has been given the designation *BAR 2510*. It is 480 mm high and weighs app. 7.5 kg.

Floor switchboards

The single position floor switchboards are made in two sizes, one with a capacity of 100 lines, Fig. 12, one with a capacity of 200 lines, Fig. 13, both of them with a maximum of 20 cord pairs. Variants are obtained by placing a low or a high upper part on the same lower part.

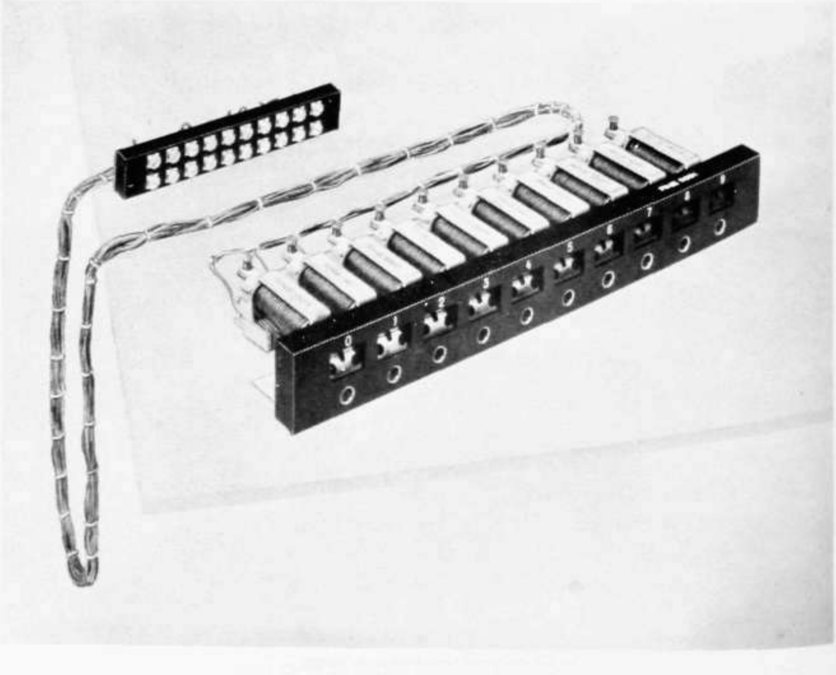


Fig. 9 X 6212
Line unit

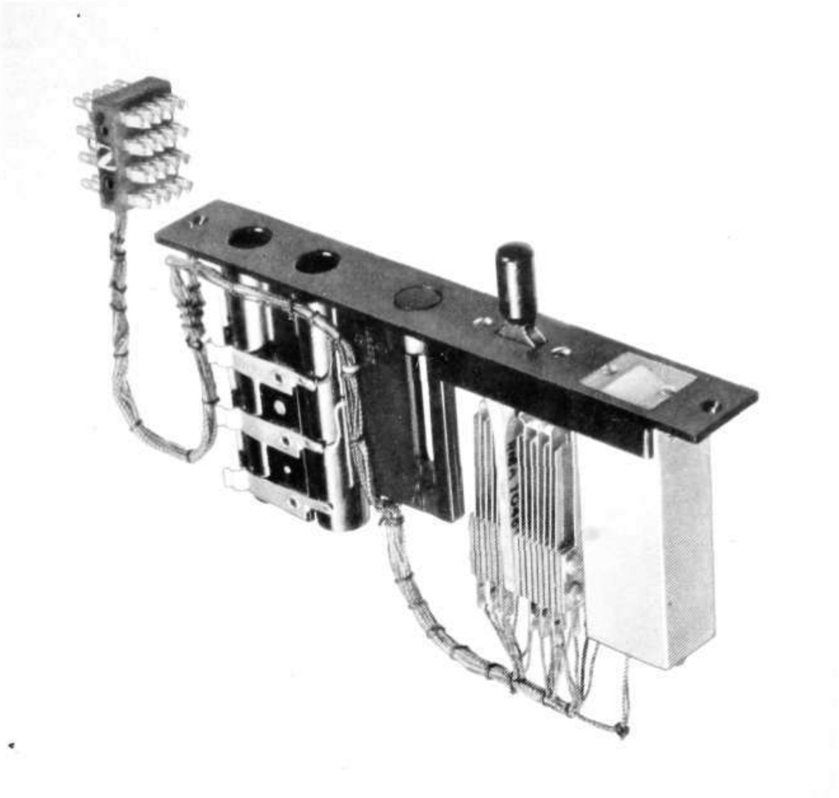


Fig. 10 X 6223
Switching set

The switchboards are executed in light oak veneer on core of laminated wood, with the exception of the back doors which consist of light-coloured wood fibre sheet with wood frames. The desk top is covered with green linoleum, constituting an excellent writing underlay. Below the desk-top a compartment has been provided for the operator's private belongings. The height from the floor to the desk-top, in conformity with Swedish standards for office furniture, is 770 mm. At the bottom the switchboard has been fitted with kick protection of sheet metal. Corners and edges have been rounded to some extent and in other respects too considerable attention has been devoted to colour and form.

The 10-line unit for the floor switchboard differs from the unit of the wall switchboard only in respect of the shape of the connecting cable. Here too all the component units of the switchboard are alike. Thus right-hand and left-hand executions are no longer to be had.

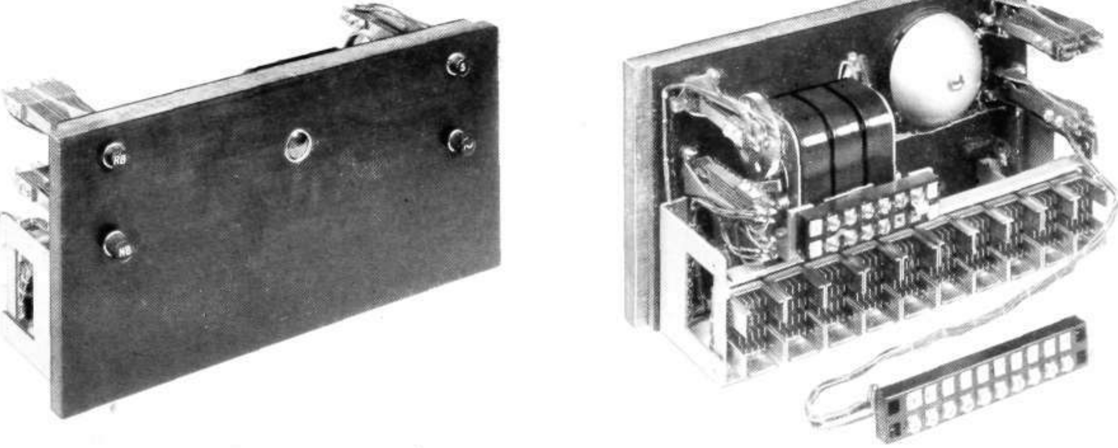


Fig. 11 X 7417
Position set
for wall switchboard, right seen from behind

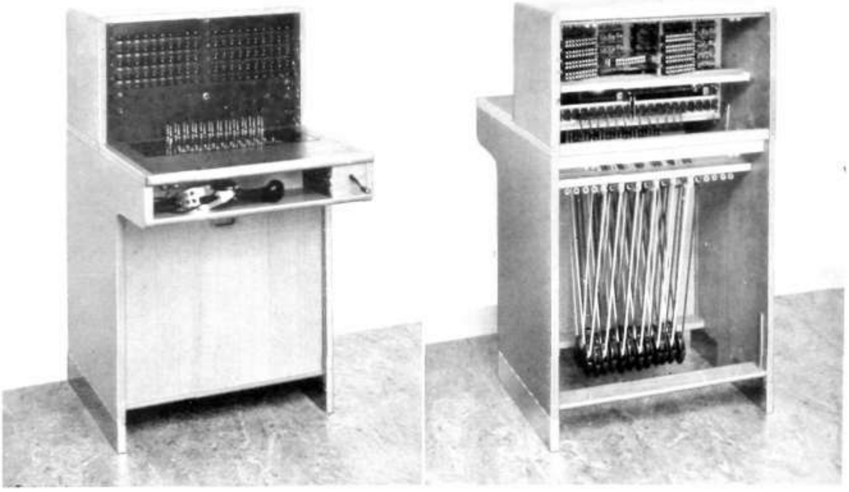


Fig. 12 X 6210

Floor switchboard ABK 2010

for up to 100 lines and 20 cord circuits, at right with back removed

The switching set for the floor switchboard is exactly the same as for the wall switchboard, see Fig. 10.

The position set, Fig. 14, for the floor switchboard is in the main the same as the unit for the wall switchboard. For practical reasons, however, the hand generator has been taken out and placed in front in the desk top. In addition, the connection of the operator's telephone has been made with 4-pole plug, located at the left under the desk top. The floor switchboard is normally delivered with the new headpiece transmitter-receiver, but of course a handset can also be used.

The terminal blocks for the 10-line units and position unit are fitted so that they are easily accessible from the back of the switchboard.

The new floor switchboard has been given the designations *ABK 2010* and *ABK 2020* for the 100 och 200 line switchboards respectively. The dimensions are: height 1110 mm and 1290 mm resp. width 634 mm depth 765 mm.

The net weight for a switchboard *ABK 2010* with 100 lines and 12 cord circuits is app. 66 kg. The corresponding switchboard *ABK 2020* is app. 5 kg heavier, while an *ABK 2020* with 200 lines and 19 cord circuits weighs app. 86 kg.

As stated earlier, all these switchboards are capable of extension. Consequently in a switchboard not completely fitted up the unoccupied space must be covered in one way or another. For this purpose special covering strips of bakelite have been designed, one for a 10-line unit and one for a switching set.

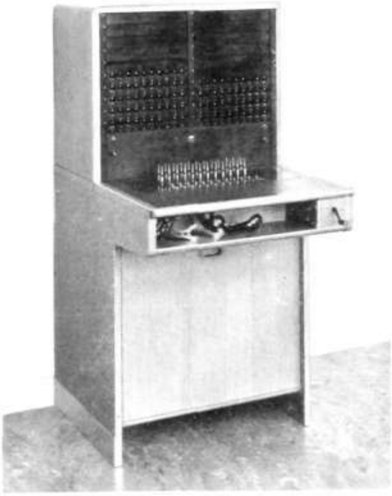


Fig. 13 X 4445

Floor switchboard ABK 2020

for up to 200 lines and 20 cord circuits

Circuit diagram

The switchboards without multiple, *i. e.*, wall switchboard *ABH 16* and floor switchboard *ABK 20* are connected up according to the same diagram, Fig. 15. The dial *D* and the relay *DR* are not normally comprised in the switchboards. They are provided only in those isolated cases when the switchboard is to be equipped with exchange lines to automatic main exchange, in which event the dotted connections are also fitted.

The connecting process for the establishment of a call is in the main as follows:

The suscriber calls the exchange by turning the crank of his telephone instrument. The ringing current thereby produced causes the calling indicator *CI* to drop, this providing a distinct visual signal for the operator. If the key *NB* is operated, there is also given at the same time an audible signal from the bell *B*. The operator takes an unoccupied cord circuit, connects the speaking and ringing key in position *SK* and plugs the answering plug *AP* in the calling

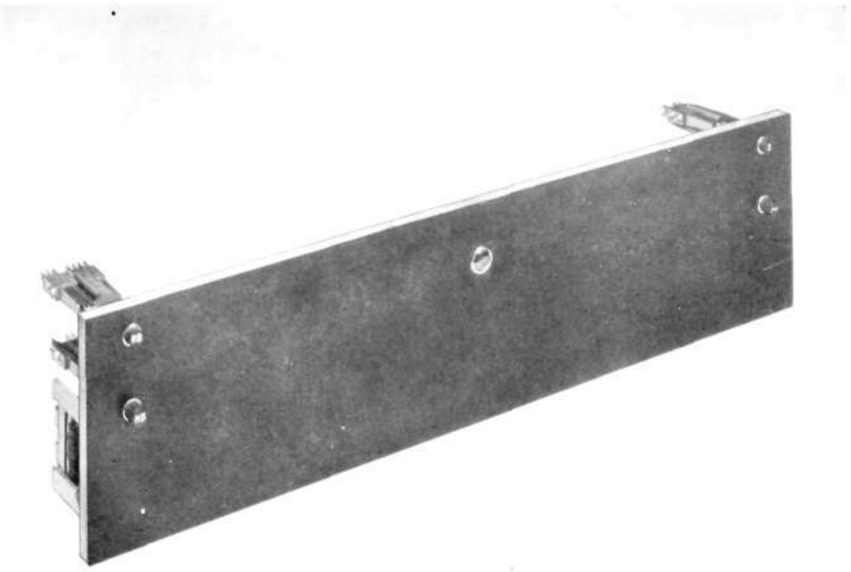


Fig. 14
Position set
for floor switchboard

X 6214

subscriber's connecting jack *J*. The action of plugging restores the drop indicator automatically, this being disconnected at the same time from the subscriber's line. The operator is now in connection with the calling subscriber and answers in appropriate manner.

Having received information of the line wanted, the operator by a quick glance sees what is the situation with this. If the line is busy, the subscriber is notified and disconnection takes place. If it is unoccupied the operator inserts ringing plug *RP* in the jack *J* of the wanted line and rings up.

Ringing may be done in two ways. One is, with the key thrown to position *SK*, to turn the crank of the switchboard's generator *HG*, whereupon ringing current is automatically transmitted over the ringing cord to the subscriber.

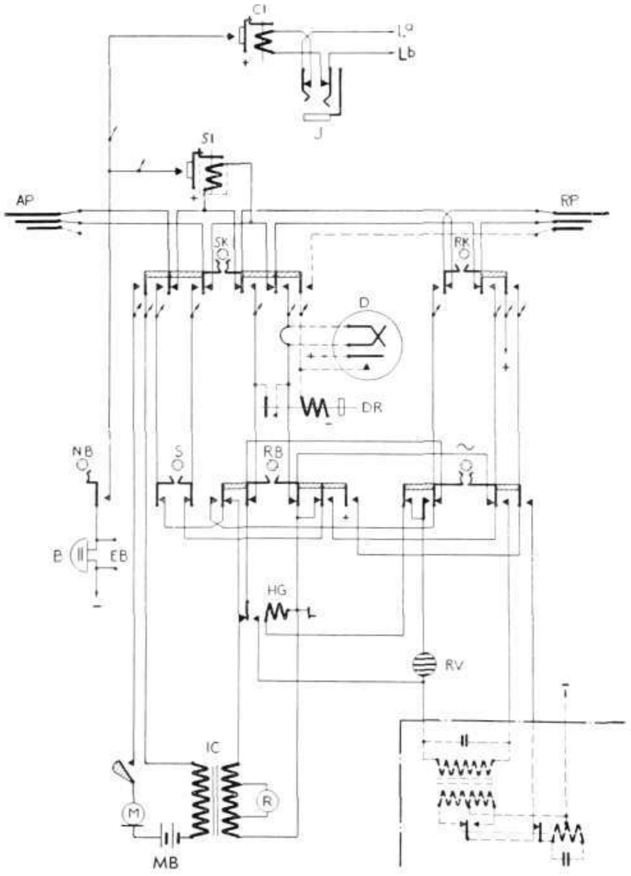


Fig. 15
Circuit diagram
for ABH 16 and ABH 20

X 6218

AP	answering plug with cord	
B	bell	
EB	extra bell	
CI	calling indicator	= combined indicator and jack
J	connecting jack	
HG	hand generator	
IC	speech transformer	
La—Lb	subscriber line	
MB	microphone battery	
M—R	micro-telephone	
NB	night bell key	
RB	ringing back key	
RK	ringing key	= 3-position key
SK	speaking key	
RP	ringing plug with cord	
RV	ringing visual	
S	splitting key	
SI	clearing indicator	
~	pole-changer key	

The other way, which requires that a pole-changer is connected, is to throw the key from position *SK* to position *RK* and keep it there as long as ringing signal is to be transmitted. In both cases the ringing visual shows white as sign that the line loop is closed and that ringing current is being transmitted. When ringing signal has been transmitted in one of these ways the key is restored to home position and the connection is established. On account of the poor supervision occurring with all L. B. switchboards the operator, however, should after 8—10 s break in on the cord circuit to make sure that the called subscriber has answered and that the call is proceeding.

During conversation the cord circuit clearing indicator is connected in between the speaking wires. Consequently when one of the subscribers rings off at the close of the conversation the clearing indicator falls, giving the operator a distinct visual signal and, if connected, an audible one as well. The operator connects herself in for a moment on the cord circuit by throwing the key to position *SK*, thereby restoring the clearing indicator. After the operator by listening has made sure that the call really is terminated disconnection may be carried out.

The above-described connecting process may be regarded as the normal. Its feature is that the operator speaks only with the A-subscriber and rings only to the B-subscriber. In exceptional cases, however, the operator may need to speak with the B-subscriber without the A-subscriber hearing and this is made possible by the splitting key *S*. In some cases it may be necessary for the operator to ring up the A-subscriber again and this is possible with the ring back key *RB*.

Accessories

A manual L. B. telephone switchboard of the kind described above is not complete without certain accessories, mainly current supplies of various kinds.
Thus for the operator's speaking device there is required a microphone battery of 3 V, suitably made up of dry cells.

For the alarm circuit and pole-changer, if any, there is further required a signal battery of 4.5 V, this too consisting of dry cells. Pole-changer for producing the necessary ringing current is not absolutely necessary for the functioning of the switchboard, but it facilitates operation so considerably that it is advisable.

Packing

Owing to the extent to which the principle of units for lines, cord circuits and position equipment has been carried out, it is a very simple matter to fit up a telephone switchboard. It is also more easy to rationalise the manufacture of units and the keeping of stocks is facilitated very much, as in future it will not be necessary to hold complete switchboards in stock but the switchboards can be delivered in parts. The assembly of the switchboards can easily be done by a fitter with no other tool than a screwdriver.

A telephone switchboard with cords will in future be delivered in the following parts:

1. a switchboard frame, whole for wall switchboards and in two parts for floor switchboards;
2. a number of 10-line units, each one in its own carton;
3. a number of switching sets, likewise in cartons;
4. a position set, either packed in separate carton or inserted in the switchboard frame;
5. a number of cords and pulleys wrapped in parcels;
6. a carton with the requisite cover strips, handset hook, generator crank, screws etc.
7. miscellaneous accessories such as microtelephone, batteries, pole-changer etc.

The whole outfit is packed together in a suitable case. The new method of packing will also reduce risk of breakage in transport.

New Single Channel Carrier Frequency Telephone System for Open-wire Lines

E EKLUND, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

U.D.C. 621.395.44.

A new single channel frequency system ZAF 11 has been developed by Telefonaktiebolaget L M Ericsson. This system replaces the older system ZL 400, described in Ericsson Review No 2/1936, 250 equipments of which have been delivered to 11 countries. By the application of advanced technics of filter design and modern elements of construction the dimensions and weight of the new system have been reduced considerably compared with those of older systems. The system ZAF 11 will hereby turn out more economical even for such a short distance as about 58 km. The range is 700 km without intermediate repeaters when using an open-wire circuit of copper wires with a diameter of 3 mm.

Frequency Allocation

The frequency allocation of the new system is almost the same as for the older system ZL 400. The frequency allocation is shown in Fig. 1. The carrier frequencies which are 6.3 and 10.2 kc/s, are suppressed by the modulators. On the line only the lower side bands are transmitted corresponding to the voice frequency range 200—2700 c/s. Thus the frequency bands are, transmitted by A-station 3.6—6.1 kc/s, transmitted by B-station 7.5—10.0 kc/s. The low-pass branch of the line filter has a cut off frequency of 3.0 kc/s.

Transmission Properties

An over-all attenuation curve is shown in Fig. 2 referring to the carrier frequency communication. Apparently the over-all attenuation is practically constant within the frequency range 200—2700 c/s.

The range or repeater section respectively is given below, calculated for copper wire lines and for a maximum line attenuation of 5 nepers:

conductor diameter mm	*range km*
2.5	500—550
3.0	600—700
4.0	750—850

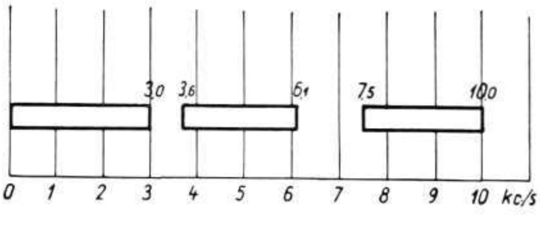
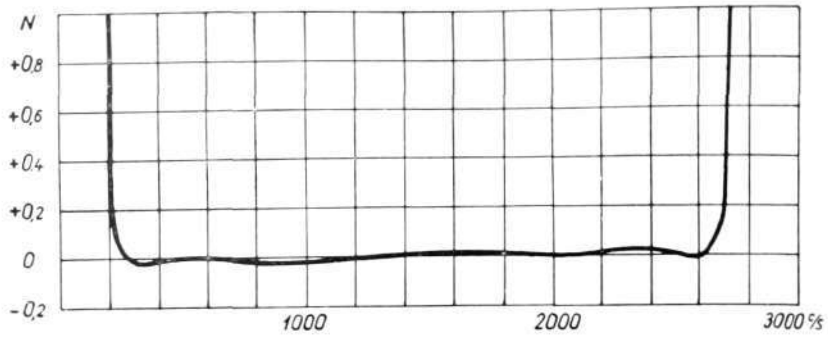


Fig. 1 Z 21024
Frequency allocation of single channel carrier frequency system, type ZAF 11

Fig. 2 Z 21025
Over-all attenuation from fork to fork



Main Properties

The main properties of the new system is given below:

number of carrier frequency communications .... = 1
transmitted voice frequency band .. = 200—2700 c/s
frequency range on the open-wire line = 3.6—10.0 kc/s
output level on the line .... = alternatively + 2.0 + 0.7 or ± 0 nepers
lowest admissible input from the line = — 3 nepers
range or repeater section alternatively when using a 3 mm copper line .. = 700 km
maximum line attenuation of a repeater section .... = 5.0 nepers
input and output impedances ...... = 600 ohms

The Equipment of the Terminal Station

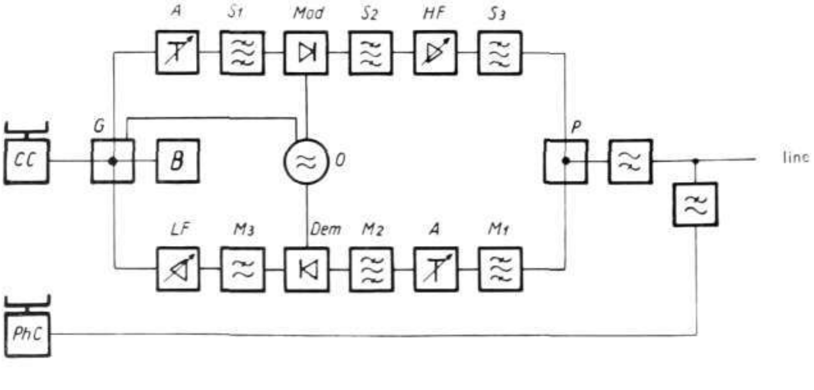
The simplified block schematic of Fig. 3 shows the design of a terminal station and how it is connected to the line and the subscriber.

Having passed the four wire termination equipment consisting of a relay equipment and a resistance bridge the voice frequency currents of the subscriber's set *CC* pass a variable attenuation *A* on the transmitter side, see Fig. 3. Thereafter the currents pass the transmitter band pass filter *S1* which admits the frequency band 200—2700 c/s. By this the modulator is protected against the ringing currents which may eventually enter the transmitter part of the apparatus. The modulator consists of copper oxidule rectifiers. Here the voice frequencies are modulated with a carrier frequency of 6.3 kc/s in the A-station or of 10.2 kc/s in the B-station.

The carrier frequencies are suppressed by the balanced modulator bridge and only the lower side band passes through the transmitter band filter *S2*. This side band is 3.6—6.1 kc/s in the A-station and 7.5—10.0 kc/s in the B-station. The transmitted side band is then amplified by the transmitter amplifier which is negatively fed back and is by this given a correct frequency response and stability. The transmitter amplifier may be regulated to three different amplifications which give an output level of 0, + 0.7 or + 2.0 nepers. After having passed another transmitter band filter *S3* the side band passes a compensating network and the line filters on to the line.

Fig. 3 X 6224
Block schematic of terminal station

A	variable attenuator
B	balance
CC	carrier frequency communication
Dem	demodulator
G	four-wire termination
HF	transmitter amplifier
LF	low frequency amplifier
M	receiver filter
Mod	modulator
O	oscillator for 3 frequencies
P	compensating network
PhC	physical channel
S	transmitter filter



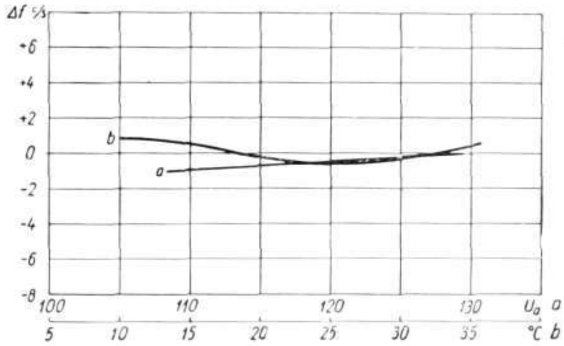


Fig. 4 Z 21027

Oscillator stability at variable anode voltage (a) and variable temperature (b)

The incoming side band passes the line filters, the compensating network and a band pass filter *M1* on the receiver side. After this a variable attenuator is passed containing 10 × 0.4 nepers and one more receiver band filter *M2*.

After the demodulator the voice frequency currents produced therein pass a low pass filter and are amplified in a low frequency amplifier with its amplification variable in 10 steps of 0.1 nepers. After the low frequency amplifier the currents pass the four-wire termination equipment on to the subscriber's set. It is possible to disconnect the four-wire termination equipment and run the system as a four-wire circuit.

The ringing is done according to the same principles as used in LM Ericsson's normal voice frequency ringing system with a constant frequency of 500 c/s. The voice frequency ringing receiver is combined with the low frequency amplifier. The rectified ringing tension gives an augmentation of the anode current in one of the valves of the amplifier which is connected in series with a relay. This relay transmits an A. C. current with a frequency of 20 c/s to the subscriber's set.

The ringing voice frequency 500 c/s is produced by an oscillator comprising one single valve. Moreover this oscillator gives the two necessary carrier frequencies 6.3 and 10.2 kc/s. The frequencies are stabilized by means of current-piloted resistances. This makes the oscillator more independent of alterations of the characteristical properties of the valve and stabilizes the output power. The oscillator coils are made with temperature-compensated dust iron cores. The stability curves of the oscillator are shown in Fig. 4.

Intermediate Repeater

A simplified block schematic of an intermediate repeater is shown in Fig. 5. The repeater contains only one single amplifier which is common for both directions.

After having passed the line filters, where the physical channel is separated from the carrier frequency channel, the incoming frequency band of the direction *A* to *B*, from left to right in Fig. 5, passes the directional filter *AB1* and enters the input transformer of the common amplifier via a variable attenuator with 10 steps of 0.4 nepers. The input transformer is designed as a differential transformer in order to make the two directions independent of the impedances of one another. Besides the variable attenuator of 10 × 0.4 nepers there is a push button switch by which an attenuation of 0.2 nepers may be connected in or out. The amplification may thus be regulated in steps of 0.2 nepers. The maximum amplification is 5 nepers.

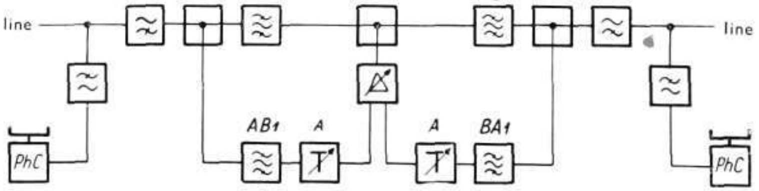


Fig. 5 X 6225

Block schematic of intermediate repeater

A	variable attenuator
AB1, AB2	band-pass filter direction A—B
BA1, BA2	band-pass filter direction B—A
PhC	physical channel

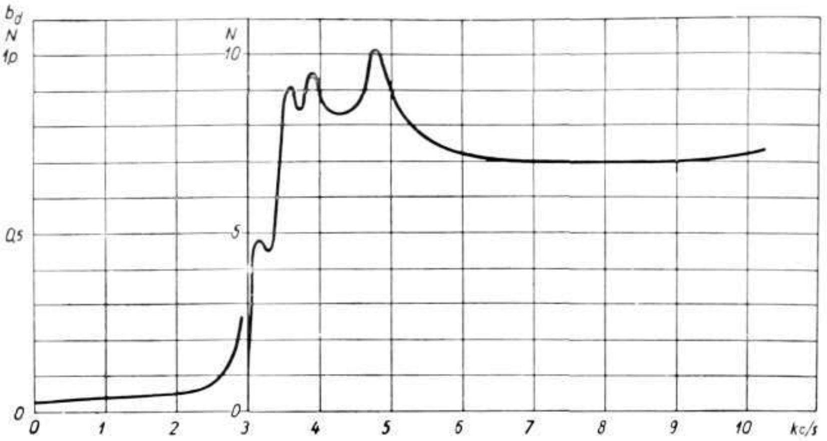


Fig. 6 Z 21029

Attenuation of low-pass branch of line filter

The amplifier contains two valves and is negatively fed back. Thus the production of harmonics is very small and the stability great. After the amplifier the frequency band passes the directional filter *AB2* and thereafter through the line filters on to the line.

In the opposite direction *B* to *A* the progress is analogous.

Equalizing Equipment

The line attenuation varies with the frequency. It will be equalized in the receiver amplifier of the terminal station as well as in the repeater station by making the negative feed back and thus the amplification dependent of the frequency by suitable design of the feed back elements. In the receiver amplifier as well as in the amplifier of the intermediate repeater tuned resonant circuits are used in the feed back equipment. These resonant circuits will compensate for the augmentation of the attenuation in the vicinity of the cut off frequencies. Besides the slope of the amplification curve can be varied by connection of condensers.

Line Filters

The low-pass branch of the line filter has a cut-off frequency of 3 kc/s. The attenuation curve is shown in Fig. 6. The high-pass filter has a cut-off frequency of 3.45 kc/s. The attenuation curve is shown in Fig. 7.

The balancing filters are always delivered. They are necessary in the terminal stations as well as in the repeater stations when the physical circuit will be repeatered. Also filter imitations and the corresponding balancing devices are always delivered. They are necessary when the system serves on one side circuit of a quad. All these filter devices are built-in in the terminal equipments as well as in the intermediate repeater equipment. The line transformers can also be connected inside the line filters. The line filter equipment of the system *ZAF 11* is shown in Fig. 8. Every terminal station has one and every repeater station such filter equipments.

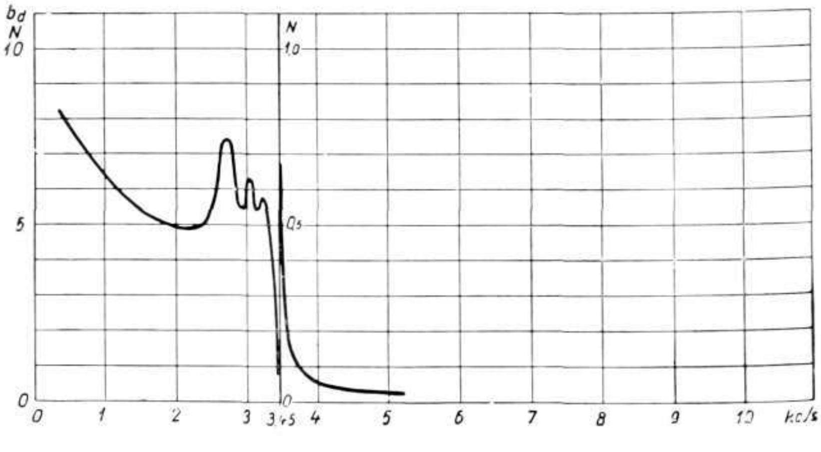


Fig. 7 Z 21030

Attenuation of high-pass branch of line filter

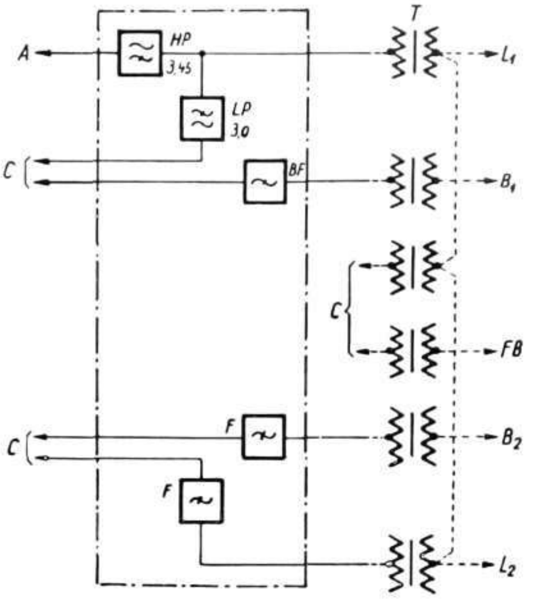


Fig. 8 Z 21031

Line filter equipment and connection to line transformers

A	to compensating network and directional filters
B_1	to line balancing network 1
B_2	to line balancing network 2
BF	VF balancing filter
C	to switchboard or two-wire repeater
F	filter compensation
FB	to phantom-balancing network
HP LP	line filter
L_1	to line 1
L_2	to line 2
T	line transformers

Supervisory Arrangements

All tensions, levels and anode currents may be measured by one common instrument by means of a switch. This switch has positions for the measurement of filament voltage, relay voltage, anode voltage, the anode current of every valve, transmitted level, received level, carrier frequency level in the transmitter and in the receiver.

Moreover a handset makes it possible by means of some switches to communicate with the subscribers at near and far ends of the carrier frequency communication as well as of the physical communication. It admits also monitoring.

By means of a U-link strip it is possible to execute special measurements directly on the line side as well as on the subscriber's side. Finally alarm is given if the mains voltage fails or if any fuses are blown.

Power Supply

The single channel system *ZAF 11* may be delivered with or without a mains supply set to deliver the necessary working voltages: 130 V anode voltage, 24 V relay voltage and 21 V A. C. voltage for the filaments. The mains supply set which is shown in Fig. 9 and 10, is built so that it may be mounted in the equipment or taken away very simply without any soldering.

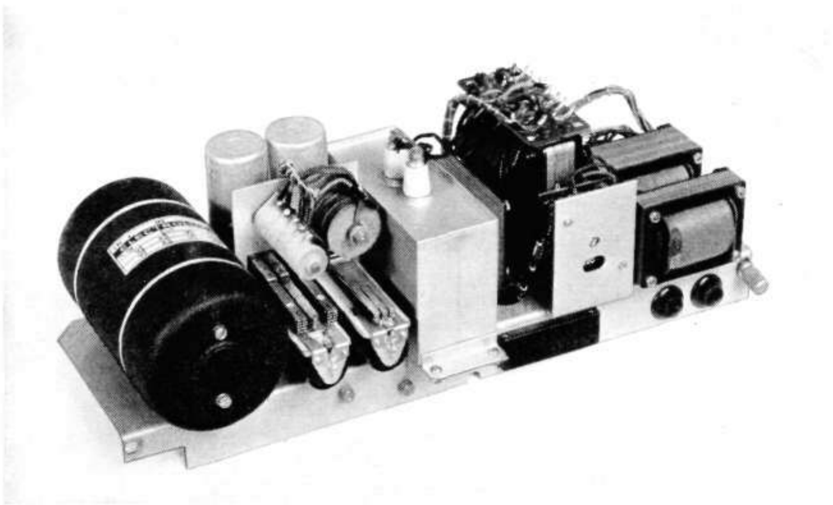


Fig. 9 Z 21022

Mains supply set with emergency converter

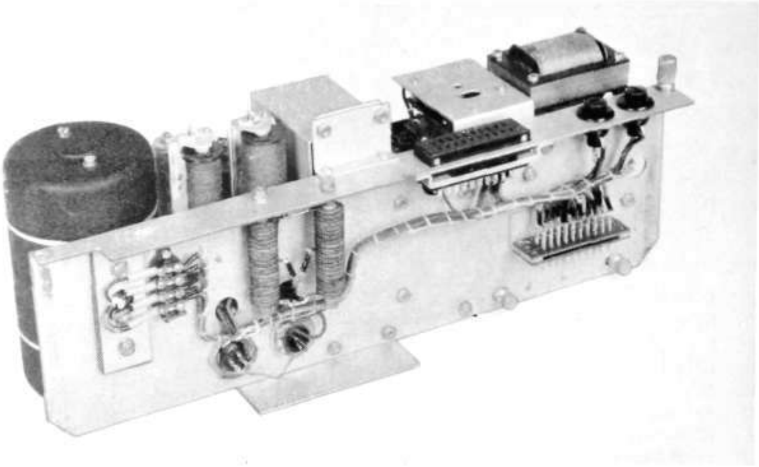


Fig. 10 Z 21023
Mains supply set with emergency converter
seen from below

When the mains fail a built-in relay connects automatically the 24 V station battery. The filament current 21 V is got by means of a series resistance from the battery and the anode voltage by means of a built-in converter 24 V D.C./130 V D.C. The mains supply set may be switched to match the mains voltages 110 V, 150 V and 220 V of 50 c/s A. C. It has a magnetical voltage regulation device and is therefore within large margins independent of the mains voltage variations.

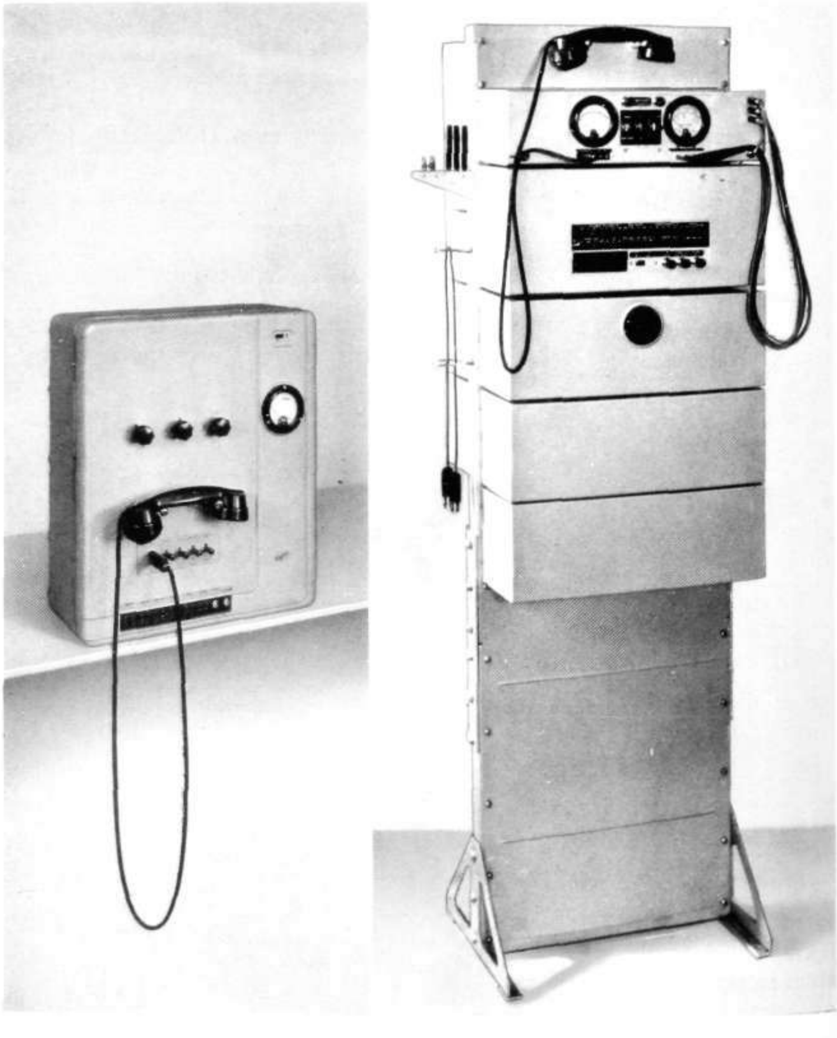


Fig. 11 X 6227
Terminal equipment
left type ZAF 11, right the older type ZL 420

The current consumption is:

	terminal	repeater
working on A.C. mains	40 VA	35 VA
» » 24 V battery	1.4 A	1.3 A
» » 24 V and 130 V batteries	24 V 0.40 A 130 V 0.03 A	0.40 A 0.02 A

Mechanical Design

The terminal equipment as well as the intermediate repeater are fitted in cast metal boxes of aluminium alloy of the size: width 451 mm, height 530 mm, depth 190 mm. The weight incl. mains supply is 56 kg.

All control devices are placed on the front side as shown in Fig. 11 to the left. The boxes are designed so that they may be mounted in normal bays by means of iron bands on their rear side. The compact but surveyable mounting of a terminal equipment is shown in Fig. 12.

Valves

In the system only one valve type is used, *RTR 4142*, with the following characteristics:

filament voltage	5.25 V
» current	0.380 A
anode voltage	130 V
» current	15 mA
grid bias	—8 V
slope	2.0 mA/V
internal resistance	0.1 MΩ

The terminal equipment has four and the intermediate repeater two valves coupled in series.

By-Pass Equipments

If the physical channel is to be taken out at an intermediate station on the line but the carrier frequency channel has to pass, a by-pass equipment, type ZCT *1201* or *1202*, must be used. This consists of two normal line filters, the high-pass filters of which are connected in series by means of a shielded transformer. The by-pass equipment also has a jack panel and a connecting panel.

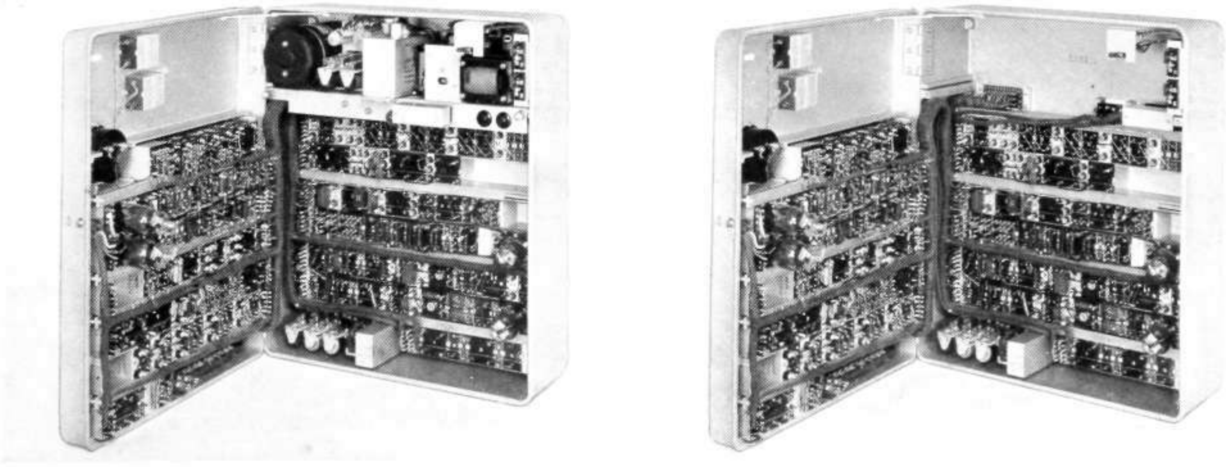


Fig. 12 X 7419

Terminal equipment

left with, right without mains supply set

It is fitted in a cast metal box of aluminium alloy, which along with the terminal equipment can be mounted in normal bays. In case a two-wire repeater is inserted in the physical channel a similar by-pass has to be connected to its balance side.

Catalogue Codes

code	number of balancing filters	power supply	transmitter frequency range	kind of station
ZAF 1111	1	A. C. mains 50 c/s	3,6—6,1 kc/s	terminal
ZAF 1112	—			
ZAF 1113	1	battery		
ZAF 1114	—			
ZAF 1121	1	A. C. mains 50 c/s	7,5—10,0 kc/s	
ZAF 1122	—			
ZAF 1123	1	battery		
ZAF 1124	—			
ZAF 1131	2	A. C. mains 50 c/s	—	intermediate repeater
ZAF 1132	—			
ZAF 1133	2	battery		
ZAF 1134	—			

Example:

ZAF 1111 is a terminal station with the transmitted frequency range 3.6—6.1 kc/s provided with a balancing filter for the use of a two wire repeater on the physical circuit and designed to be supplied with A. C. current from the 50 c/s mains.

Electric Interlocking Plant at Sakskøbing Station

CHIEF SIGNAL ENGINEER O GØTZSCHE, COPENHAGEN

U.D.C. 626.257

Towards the end of 1945 a new electric interlocking plant was put into service at Sakskøbing Station, and as the plant is the first in Denmark to use the all-relay interlocking machine of L M Ericssons Signalaktiebolag, Stockholm, the following description may be of interest.

The employment of interlocking plants on the Danish private railways, which mostly consist of sections with small traffic, is rather unusual and a few years ago the Lolland Main Line, serving the market towns of Nakskov, Maribo, Sakskøbing and Nykøbing Falster was no exception to the rule, though this line has a comparatively large passenger and goods traffic. For instance, quite a number of special trains are run on the section in the sugar beet season, when the many thousands of tons of beet grown on the fertile fields of Lolland provide the line with large loads.

At the beginning of the war, when traffic and thereby the revenue of the line, after falling off for some years, began again to rise, the management of the line (Det Lolland-Falsterske Jernbaneselskab, the Lolland Falster Railway Co., at Maribo) decided the time was ripe for the introduction of interlocking plants at the more important junction stations. To begin with 3 rural stations were provided with mechanical interlocking plants of fairly simple design.

When the turn came of providing Sakskøbing with interlocking plant it was originally proposed to continue with the same simple type of plant, but the urban character of the station involving considerable shunting and train marshalling, both during and outside the regular traffic, imposed such demands on rapid and labour-saving operation of the plant that this form of construction was not capable of satisfying the requirements of the traffic. Among other things it was required that some of the points could be shifted for train routes from the central apparatus, whereas those same points should be operated on the spot for train marshalling.

The only satisfactory arrangement therefore was the employment of electric interlocking plant and after negotiation with LM Ericsson A/S, Copenhagen, the decision was made for a plant with all relay interlocking machine and in general of about the same type as that of which the Swedish State Railways had ordered 25 in 1941.

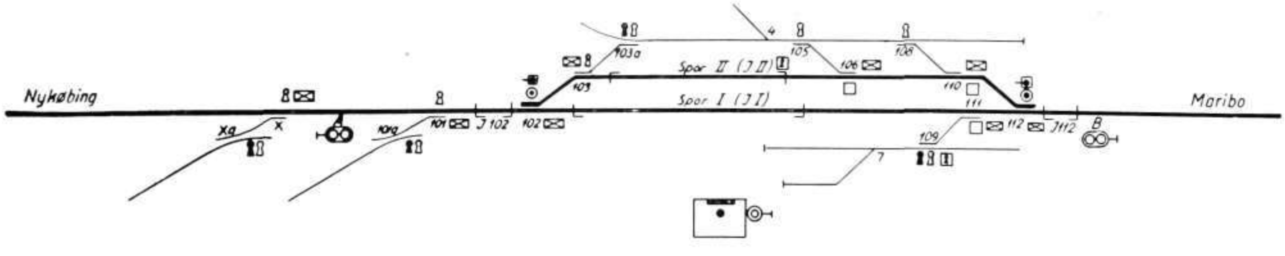


Fig. 1 X 7416
Station lay-out

- ◉ electric point machine
- ⊡ local switch for same
- ☐ electric point lock
- ⊡ electric key central with keys locked in
- ❚ lock on lever stand with key locked in
- 8 » » » » without » » »

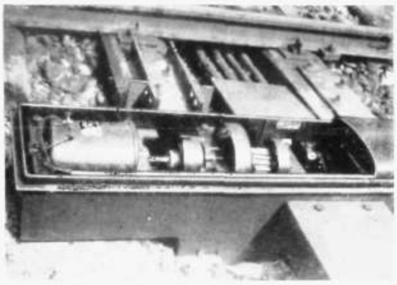


Fig. 2
Point machine
with cover removed

X 4440

Among the advantages obtained with the choice of this type of apparatus was that the central apparatus could be housed in the telegraph office with no other reconstruction than the addition of a window bay about 0.8 m deep, an arrangement that would in any case have been necessary to provide a view of the centrally operated points from the central apparatus.

Execution

An idea of the track system and the lay-out of signals, points and track locks may be obtained from Fig. 1. The figure shows the track diagram for the station operating plan. As may be seen from the diagram the entrance signals are made as daylight lamp signals which can display »danger» and »clear». *In these signals the Danish State Railways standardized 30 V 15 W lamps* are used.

For central operation of the entrance points 102 and 112, the Signalbolaget point machines with built-in lock are employed. The local operation of these points is done from local switches fitted on stands beside each point. Before local operation can be undertaken release must be given from the central apparatus. Release is notified to the staff on the spot by a control lamp fitted in the local switch lighting up. The mounting of the point machine at the points may be seen from Fig. 2, showing the engine with cover removed.

The centrally operated points are protected against premature shifting in the usual way with insulated rail in connection with track relays that break the circuit to the operating relay of the point when the insulated rail is entered.

In addition to the insulated rails provided before the centrally operated points, protection against signal being given to a train route already containing train is provided by establishing track insulation of the main tracks I and II for the length of the platforms. By means of a track relay connected via the entrance point control relay contacts to the train route to which the points lead, the insulated track is in relation to the giving of signals, so that the signal can only be set at »clear» when the insulated section is unoccupied. As the insulation therefore is not continuous, the acting stationmaster is not freed from supervision of the train routes.

The fixing of the train routes is done by means of two supervisory current blocking relays — one for each signal — which break the operating and unlocking circuits when a signal is changed to »clear».

The train route unlocking is done automatically when the train entering has passed the track insulation at the entrance points and has entered the insulated train route track.

In selecting the method of locking for the individual points various considerations, both economical and technical in respect of tracks and safety, have had to be taken into account.

For points in the immediate neighbourhood of the interlocking machine and for points to sidings used comparatively seldom there is employed key locking on the wellknown key-lock principle by which the insertion of a master key at the interlocking machine ensures the correct setting and locking of the points. The points in the main line tracks are moreover provided with a Bruchsal point lock for fixing the point tongue setting.

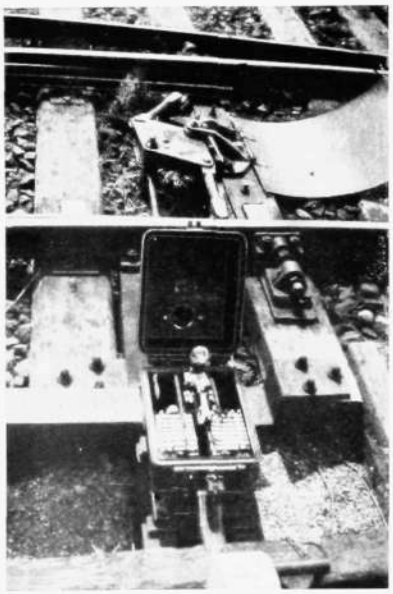


Fig. 3
Point lock
with cover open

X 4441

For the other points in main line tracks use is made of electric locks of Signalbolaget's point lock type in conjunction with Bruchsal service lock, as may be seen from Fig. 3 where the electric point lock is shown with cover open.

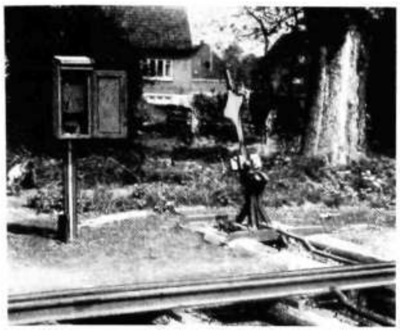


Fig. 4 X 5442
Key locked points with electric key central

The rest of the centrally locked points are located in sidings and are of such design that fitting with point locks in conjunction with electric locks cannot be done in satisfactory manner, and as these points only occur as safety points, only traversed during shunting, it was decided in this case to have key locking without point locks. Owing to the remoteness of these points from the interlocking machine, however, it was not possible here to make use of the usual arrangement with locking by master key direct at the interlocking machine, and instead there was adopted an arrangement with locking under a lock controlled by electric block magnet (»electric key central»), fitted in a box at the points concerned. The electric key central is thus connected with the interlocking machine in that the key for the points must be locked in the key central before signal can be given and it can only be taken out when the signal is again moved to »danger» and by operation of a contact at the interlocking machine the way has been cleared for unlocking. On Fig. 4 may be seen such a key-locked points with their electric key central.

The Interlocking Machine and the Internal Equipment

A brief description will now be given of the interlocking machine and the internal equipment associated with it. A more detailed description of the interlocking machine itself, which as stated is of LM Ericsson's all-relay type, is not called for here, as the machine does not differ from the »press-button interlocking machine» used in Sweden, described in earlier numbers of this Review. It is sufficient to recall that the aim of the design has been to produce a central apparatus for small stations, giving the simplest possible operation, ensuring the interlocking advantages generally achieved with electric interlocking plants and taking up the smallest possible space.

The interlocking machine at Sakskøbing is mounted on a relay cabinet that is placed against the wall facing the platform in the window bay mentioned earlier, Fig. 5. In this way the apparatus takes up very little room in the telegraph office, while the arrangement provides a good view of the track system from the operating position in front of the interlocking machine and at the same time it is possible from the desks to keep an eye on the interlocking machine.

On the right hand side of the relay cabinet there has been provided place for a writing desk where the train journal may be kept.

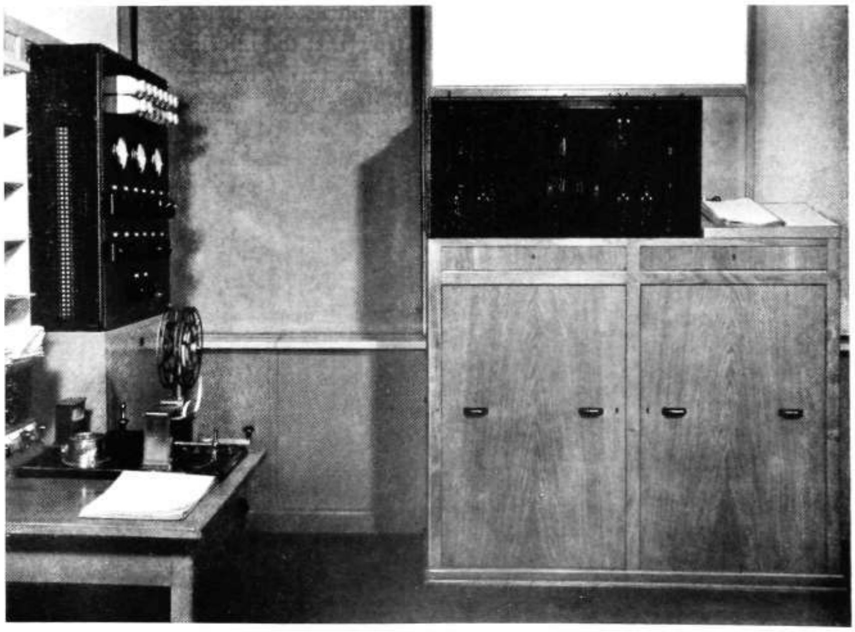


Fig. 5 X 6208
The interlocking machine at Sakskøbing

The relay cabinet is constructed of light oak and is fitted with removable front and sides, so that with these removed a good view and easy access to the relays etc. in the cabinet is obtainable.

The operating and control relays, the auxiliary relays for the centrally operated points and the track occupying relays are made as mantled relays and manufactured by LM Ericsson, Stockholm. The other relays are supplied by A/S Danske Signalindustri, Copenhagen, as unmantled relays designed for suspension on iron supports.

As all the relays, resistances and fuses, as well as the various cable terminals are fitted in the relay cabinet, complete connecting up and testing of the central apparatus and the relay cabinet could be done at Dansk Signalindustri's factory in Copenhagen, thus reducing considerably the work of erection on the spot. Fig. 6 shows the relay cabinet and the interlocking machine before despatch from the factory.

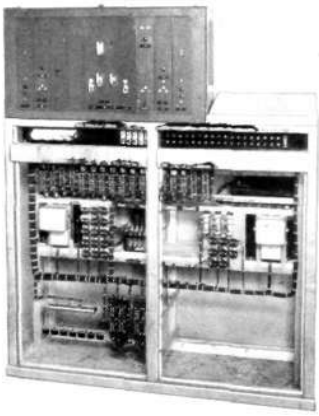


Fig. 6 X 4443
Interlocking machine and relay cabinet

Current Supply

As regards the current supply plant it should be noted that the current for the point machine motors and point lighting is taken direct from the 220 V railway power network, whereas the other current consumption is provided by a 220/45 V converter, part of it direct over 24 V Nife battery coupled to the same converter. The delivery of current takes place over the distribution panel seen at the left of Fig. 5, from which the points lighting groups are also lighted.

The cost of electricity in Sakskøbing being relatively high, special attention has been given when arranging the plant to keep the current down to a suitably small amount. Thus the daylight lamp signals are generally extinguished except at train times and only the train route lock relays have constant current. It is only when shunting and signalling are proceeding that the converter is run and the generator tension is kept regular in such a way that in addition to the current necessary for daylight lamp signals, control circuits etc. there is delivered suitable charging current to keep the battery charged. The starting and stopping of the converter is done by operation of a contact on the distribution panel in connection with an automatic starter, with a manually operated starter in reserve.

When the management of the line reached the decision to establish an electric interlocking plant at Sakskøbing there was felt some doubt whether such a complicated and finely adjusted plant would operate with sufficient reliability. Now that the interlocking plant has been in service for about ¾ year, operating satisfactorily through the bad weather of winter with snow and frost, it is with full confidence and not without fundamental experience that a start is made with a plant of the same type for the next station on the line to be given interlocking plant, that is Maribo.

Svenskradio 463 — New Radio Receiver in Estrade Model

C FREDIN, SVENSKA RADIOAKTIEBOLAGET, STOCKHOLM

U.D.C. 621.336.621

Svenskradio 463 is a new 4-valve superheterodyne of Svenska Radioaktiebolaget's make, which in respect of sound quality and range will stand comparison with receivers of very much greater size. The strong construction, described briefly below, more than fulfils the demands on a highclass product, whether for the home or export market.

Svenskradio 463 is executed in highly polished elm or mahogany in shades that best bring out the grains of the woods.

Manipulation is the simplest imaginable. One switch, one knob for strength and character of the sound, another knob for tuning to areas and stations — nothing more.

Svenskradio 463 V may be connected to 50 c/s mains, 463 LV operates on any kind of current. Both types may be switched over to most usual voltages. The unusually low power consumption, app. 45 W, makes the receiver very cheap to run.

Connections

In addition to the necessary tappings for aerial and earth there are terminal contacts for pickup. This last is connected in conveniently by the wave-length knob, the wireless part being disconnected at the same time. The high impedance of the input — Z exceeds 1 MΩ — allows of the connection of the most varied type of pickup.

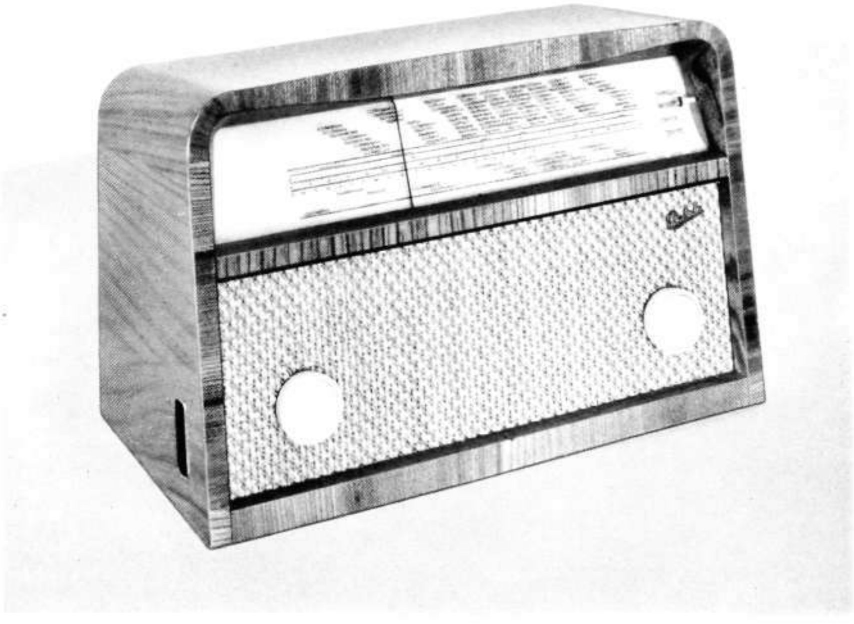


Fig. 1
Svenskradio 463

X 6226

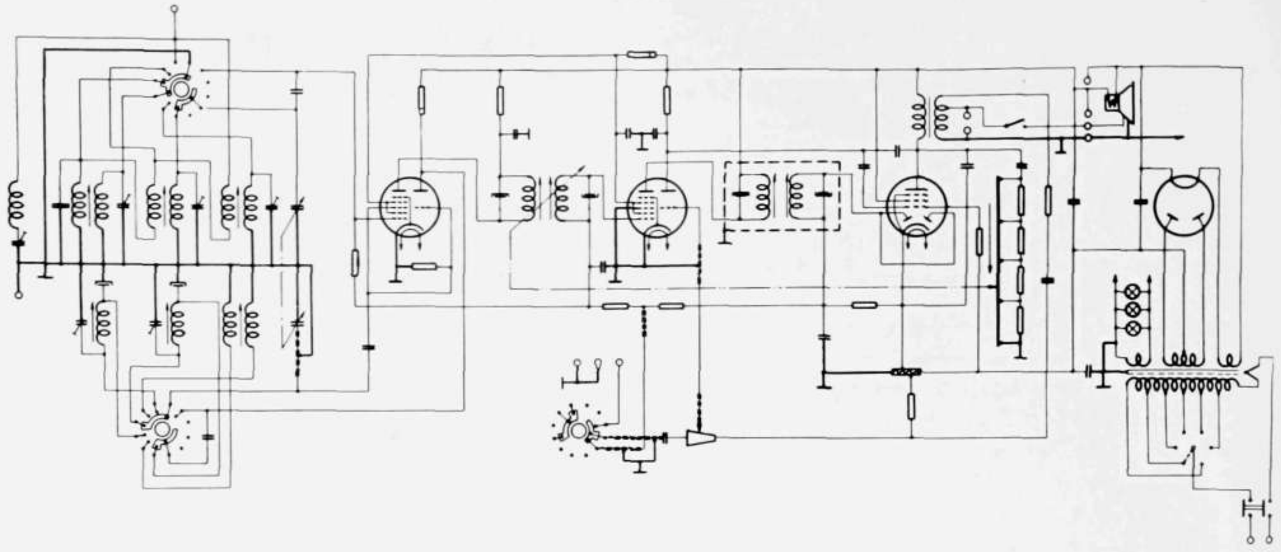


Fig. 2 X 7415
Connecting diagram for Svenskradio 463

The tapping for extra loud-speaker may be used in several ways. The extra loud-speaker — with app. 20 Ω impedance — may be connected either in parallel or in series with the loud-speaker built into the receiver, and this latter may be disconnected by pushing one of the connecting plugs right in. And, finally, this tapping is also adapted for connection of earphones.

Power Supply and Disturbance Protection

In the A. C. receiver the filament wires of the valves are coupled in parallel and are fed from a winding on the power transformer. Other windings deliver current to the rectifier D.C. valve working on the full-wave principle. The smoothing necessary after rectification is obtained by means of the loud-speaker field coil and electrolytic condensers of ample dimensions.

The valves in the universal current receiver all lie in series, after half-wave rectification the anode current is smoothed by electrolytic condensers and choke — the loud-speaker has permanent magnet.

Mains lines usually bring disturbances of high frequency nature. With a view to preventing these reaching the receiver's aerial circuit, a number of protective measures have been taken. In the power transformer the flash-over is prevented by an earthed copper screen between the primary and the secondary windings; Svenskradio 463 LV has a powerful high frequency choke for the same purpose.

Protective Devices

Svenskradio 463 has been constructed to conform with the specifications drawn up by the Swedish Electrical Material Control Institute, SEMKO, and — after thorough tests — has been passed for the Institute's »S» mark.

Besides certain figures for insulation and wiring dimensions, the stipulations require that the power transformer shall be provided with a fuse that breaks the current should the temperature in the transformer for some reason rise above the tolerated figure. Corresponding protective devices in the universal current receiver consist of a rapid acting fuse in the filament current circuit and a delayed action anode fuse of thermic type ensuring break should the anode current go beyond a fixed maximum limit.

Finally there may be mentioned a protective device for the scale illumination lamps in Svenskradio 463 LV; a thermo-relay which connects the lamps about ten seconds after switching on. It takes that length of time for the valves to get so warm that the initial high current delivery comes to an end and the current returns to its normal value.

Electrical Functions

In the preliminary circuits, mirror frequency and other undesirable signals are prevented from reaching the control grid of the mixing valve. The oscillator circuit follows the aerial circuit tuning frequency with a constant frequency distance of + 467 kc/s. The intermediate frequency signal of that value formed in the anode circuit of the mixing valve is separated in the intermediate frequency filters from other signals of neighbouring frequency. Following amplification in the intermediate frequency valve, rectification takes place in the diodes of the output valve.

The D.C. voltage, negative in relation to the valve cathodes, is filtered and redelivered to the control grids of the first valves (automatic volume control). The low frequency component is returned to the triode part of the intermediate frequency valve where it is amplified and finally impressed on the control grid of the output valve. The output valve delivers a maximum of 3.5 W power, transformed in the output transformer to a suitable impedance.

Low Frequency Amplifier and Loud-speaker

The low frequency amplifier characteristic is carefully adapted to the loudspeaker and the acoustic build-up. Correcting elements in the return connection circuit, together with the return connection changed according to the sound intensity, gives a sound that is as true as possible to nature for each grade of intensity.

The loud-speaker, field fed in 463 V and permanent in 463 LV, has an effective cone area of 200 cm² — an unusually large acting area. The suspension resonance, entirely attenuated electrically by the negative feedback, comes lower than 90 c/s.

The fidelity curve, which in the bass register in the vicinity of 60 c/s takes on a rise of 10 dB, runs straight in the middle register to the treble register where at 4000 c/s it has been attenuated 6 dB for full register. The treble can be attenuated by tone control a further 30 dB.

Technical data for Svenskradio 463

Table model in elm or mahogany.

Superheterodyne with 4 valves, 3 wave-length ranges and 6 tuned circuits. Intermediate frequency 467 kc/s.

Type *463 V* for 50 cycle mains. Type *463 LV* for all currents.

Connections for aerial, earth, pickup and extra loud-speaker.

Controls: Left knob for regulating sensitivity, pitch and band width. Right knob for tuning to stations, ranges and gramophone. Separate power switch.

Scale, 300 mm long with names of stations for medium and long wave, direct reading range indicator.

	long wave	medium wave	short wave
	690—2000 m	187—580 m	15—51 m
Max. band width for 40 dB	14—16 kc/s	16—18 kc/s	20 kc/s
» » » » 6 »	5 kc/s	6 kc/s	6 kc/s
Mirror frequency ratio	70 dB	40—60 dB	10—20 dB

Other technical data for Svenskradio 463

Data		463 V	463 LV
Sensitivity (for 50 mW output)	μV	10	20
Power consumption at 220 V	W	48	38
Do at 110 V	W	48	28
Max. output at 220 V	W	3.5	3.5
Do at 110 V	W	3.5	0.6
Starting up time	s	20	40
Loud-speaker		HF 618	HP 918
Loud-speaker effective cone area	cm²	200	200
Valve Equipment			
Mixing valve		MECH21	MUCH21
Intermediate frequency and low frequency valve		MECH21	MUCH21
Detector and output valve		MEBL21	MUBL21
Rectifier valve		MAZ1	MUY1
Scale illuminating lamps		6.5V, 0.15A	6.5V, 0.10A
Mains Voltages	V	110	110—120
		127	
		140	130
		155	150
		220	220
		245	
Weight			
Receiver with valves, net	kg	10.5	8.8
Receiver complete, packed	kg	13.1	11.4
Dimensions			
Height	mm	306	
Width	mm	470	
Depth	mm	242	

U.D.C. 621.395.33

Engqvist, E: *New Series of Manual L. B Switchboards with Cords.* Ericsson Rev. *23* (1946) No. 3 pp. 250—258.

The work of development that is constantly going on even in respect of manual telephone exchanges has now resulted in LM Ericsson's new series of extensible L.B. cord switchboards, differing rather considerably from those hitherto produced. By the introduction of brighter colours and softer lines, for instance, the character of the new switchboards as pieces of furniture has been brought out to a greater degree than was formerly the case. Moreover, as regards the component parts a distinct departure in respect of choice of material and methods of manufacture has taken place in the direction of modern moulding materials and diecasting practice. Lastly, the assembling into units of components organically associated has been still further developed. In this way there have been produced switchboards that are aesthetically attractive, durable, simple to operate and easy to extend.

U.D.C. 621.395.44

Eklund, E: *New Single Channel Carrier Frequency Telephone System for Open-Wire Lines.* Ericsson Rev. *23* (1946) No. 3 pp. 259—266.

A new single channel frequency system ZAF 11 has been developed by Telefonaktiebolaget LM Ericsson. This system replaces the older system ZL 400, described in Ericsson Review No 2/1936, 250 equipments of which have been delivered to 11 countries. By the application of advanced technics of filter design and modern elements of construction the dimensions and weight of the new system have been reduced considerably compared with those of older systems. The system ZAF 11 will hereby turn out more economical even for such a short distance as about 50 km. The range is 700 km without intermediate repeaters when using an open-wire circuit of copper wires with a diameter of 3 mm.

U.D.C. 656.257

Gotzsche, O: *Electric Interlocking Plant at Sakskøbing Station.* Ericsson Rev. *23* (1946) No. 3 pp. 267—270.

Towards the end of 1945 a new electric interlocking plant was put into service at Sakskøbing station. The plant is the first in Denmark to use the all-relay interlocking machine of LM Ericssons Signalaktiebolag, Stockholm.

U.D.C. 621.336.621

Fredin, C: *Svenskradio 463 — New Radio Receiver in Estrade Model.* Ericsson Rev. *23* (1946) No. 3 pp. 271—274.

Svenskradio 463 is a new 4-valve superheterodyne of Svenska Radioaktiebolaget's make, which in respect of sound quality and range will stand comparison with receivers of very much greater size. The strong construction more than fulfils the demands on a highclass product, whether for the home or export market.

Ericsson
LM

Ericsson Review

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New Railway Telephone Plant at Stockholm Central Station

M LINDEROTH, DEPARTMENTAL ENGINEER, ROYAL BOARD OF RAILWAYS, STOCKHOLM

U.D.C 621.395.26
656.254.15

A new private branch exchange on L M Ericsson's OS system with a capacity of 2000 lines was installed at the beginning of 1946 for the Swedish State Railways. It replaces an earlier exchange put into service in 1936, also on the OS system, for 900 internal lines. The build up and operation of the new exchange are described in the present article, together with some historical information regarding the development and employment of the telephone in the Swedish State Railways system.

Like most branches of activity of a technical character, railway operation is at present in general going through a period of forced development. With the railways as elsewhere it is a matter of improving the efficiency of operation. New types of trains, improved types of locomotives and rolling stock, change-over to electric traction, increase of train speeds, all these constitute examples of features receiving attention from railway administrations. All these factors are of a nature to be largely of interest not only to technicians but also to the general public.

A more inconspicuous, but no less important role is played by developments in the domain of railway telephony. It is in fact true that the telephone appliances are of vital importance to operation of railways and their development must keep pace with technical railway development in general if these latter are to produce the best results.

Particulars are given below of the newly installed railway telephone plant of the State Railways. The plant covers a combined automatic and manual telephone exchange and extensive automatisation of the sectional telephone lines in district I of the State Railways.

To provide the reader with guidance to the problems associated with railway telephony and facilitate understanding of the strikingly rich variety of apparatus characterizing a complete railway telephone plant, brief historical particulars will first be given of the development and employment of the telephone on the Swedish State Railways.

History

In 1889 the first telephone switchboard was installed at Stockholm Central Station. The exchange was a single position double cord switchboard of LM Ericsson's make, arranged for single-wire inductor circuit and with a capacity of 100 lines. As the switchboard, in addition to local extensions, also had junction circuits to the commercial telephone network, it may be said that it constituted a predecessor of the private branch exchanges of today. The employment of an intercommunication telephone plant, with or without junction circuits to the commercial network, was thus adopted at an early stage by the State Railways.

In 1905 the telephone began to assume wider importance for the State Railways by the introduction of the *track telephone plants*. By »track telephone» was meant at that time an inductor party-line laid along the track and taking in stations, linesmen's houses, permanent way offices and similar places connected with the work of the permanent way men. The line also went to switchboards along the track section.

The track telephone's employment was important and appreciated as a convenient means of communication between the stations and the permanent way staff for announcements of changes in the normal running of trains and so on. Gradually the track telephone came also to be utilized for other communications such as calls between section main stations and subordinate stations. This gave rise to the need for several parallel party lines, which were mainly to be connected to stations and switchboards. These new lines, referred to as *section telephone lines*, were lengthy and as time went on they became burdened with an inconveniently large number of telephone posts. To eliminate the troublesome code signals associated with this, it was decided in 1914, as a trial, to procure Western Electric's selective calling telephone plants. This was done and in 1916 a section telephone line of this construction was connected to the telephone exchange of Stockholm Central Station. The selective calling system turned out well and a number of such section telephone lines were arranged later.

The above track telephone and section telephone lines are now comprised in the groups of lines forming what are now called *the section telephone networks*. The former section telephone lines have been re-disposed and given the designation of *line telephone lines*. With the electrification of railways there have been added and included in this group party-lines intended for the electrical operation, which have been named *power telephone lines*.

For all these section lines, LM Ericsson's decentralized selective calling telephone system (ATA 10) has been adopted as standard for the State Railways. An important demand in this connection has been that the section lines could be connected to the switchboards in a uniform manner and that the line telephones should be comprised in the number system of the automatic switchboards, in such a way that automatic long distance traffic should also be possible with these telephones. On the other hand, the track and power telephone lines should as a rule only be connected to the manual part of a telephone switchboard.

On the arrangement of section telephone lines and particularly in conjunction with the laying in cables of the telephone lines on the introduction of electrical train traction, a separate *trunk telephone network* was created for the State Railways. It may be mentioned that Stockholm Central Station received its first real trunk line in 1926.

At present the telephone exchanges of the State Railways (so far they are chiefly manual) are linked together by a trunk network of over 170 lines.

From about 1930—1931 the employment of the telephone was still further extended, as at this time it was decided that the telephone should without exception replace the telegraph, even for communications applying to traffic safety. Extension of the telephone network and the telephone equipment was the natural result of this, while at the same time the discarding of the telegraph was hastened.

Development in the telephone service of the State Railways in 1930—1940 was characterized by extension of the trunk network, the acquisition of a large number of private branch exchanges of LM Ericsson's OS and OL types and the introduction of LM Ericsson's selective calling telephone system.

Of the 20 or more automatic private branch exchanges procured about this time for the State Railways that of Stockholm was the largest. The exchange plant, taken into service in 1936, was of LM Ericsson's make and comprised an automatic exchange of OS type for up to 900 extensions, a manual switchboard with 6 positions and various equipment for public exchange lines and section telephone lines.

At the beginning of 1946, owing to insufficient capacity, the plant was replaced by a new one, this also being supplied by LM Ericsson. A brief description of this follows.

The New Telephone Plant at Stockholm Central Station

Traffic Facilities

In conformity with what has been stated in the introduction respecting the development of the telephone in the service of the State Railways, the new telephone plant has been equipped with devices for:

automatic local traffic,

automatic outgoing traffic to the public network,

automatic and manual two-way traffic with the section telephone network in district I,

manually handled traffic with the State Railways trunk network.

An important additional demand imposed was that the plant could without change in the existing equipment be later extended for country-wide automatic trunk traffic.

The functioning of the private branch exchange should naturally include facility of inquiry and transfer for public exchange calls. Moreover such facilities should be planned for the future automatic trunk connections. Pending the introduction of this, the trunk lines were to be equipped with line equipments previously used for magneto ringer calls, these comprising the following functions: automatic clearing signal on the magneto line combined with simultaneous clearing in the cord when the local subscriber replaces the handset, current feed for the local extension, facility of inquiry to the operator (by dialling one figure) and transfer of the call established to another instrument with the aid of the operator.

System and Types of Devices

The automatic private branch exchange is of LM Ericsson's OS system, but to meet the special requirements of the railways extensive new designs have had to be introduced. These are chiefly connected with the lay-out diagram, Fig. 1, though there are also mechanical and erecting innovations, Fig. 2, 3 and 4. The line finders, group selectors and final selectors as well as the

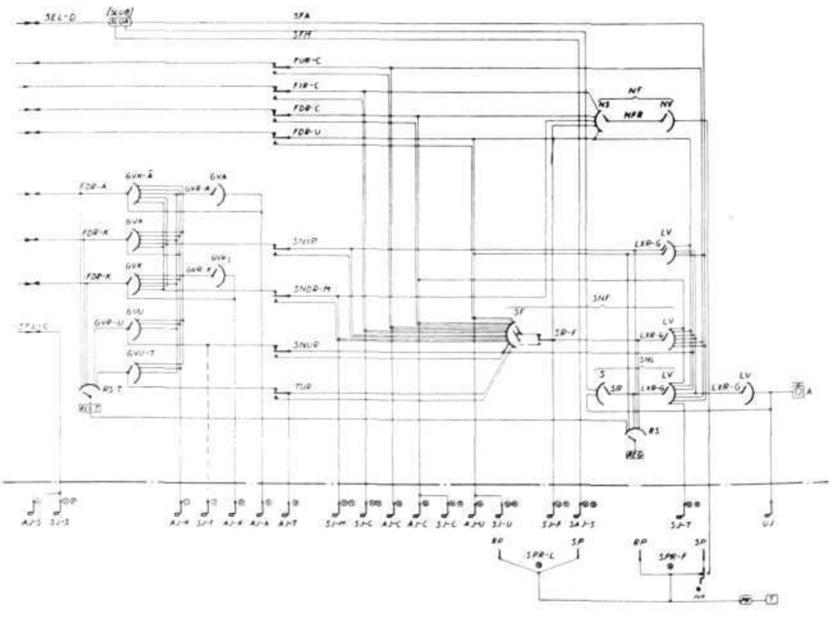


Fig. 1 X 6238

Distribution diagram

AJ	calling jack
FDR	two-way junction line
GV	group selector
K	junction exchange
LV	final selector
N	night connection device
REG	local register
REG-T	trunk register
S	finder
SF	function equipment for selective calling line
SJ	answering jack
SLU	terminal equipment for selective calling line
SN	connecting circuit
Å	terminal exchange

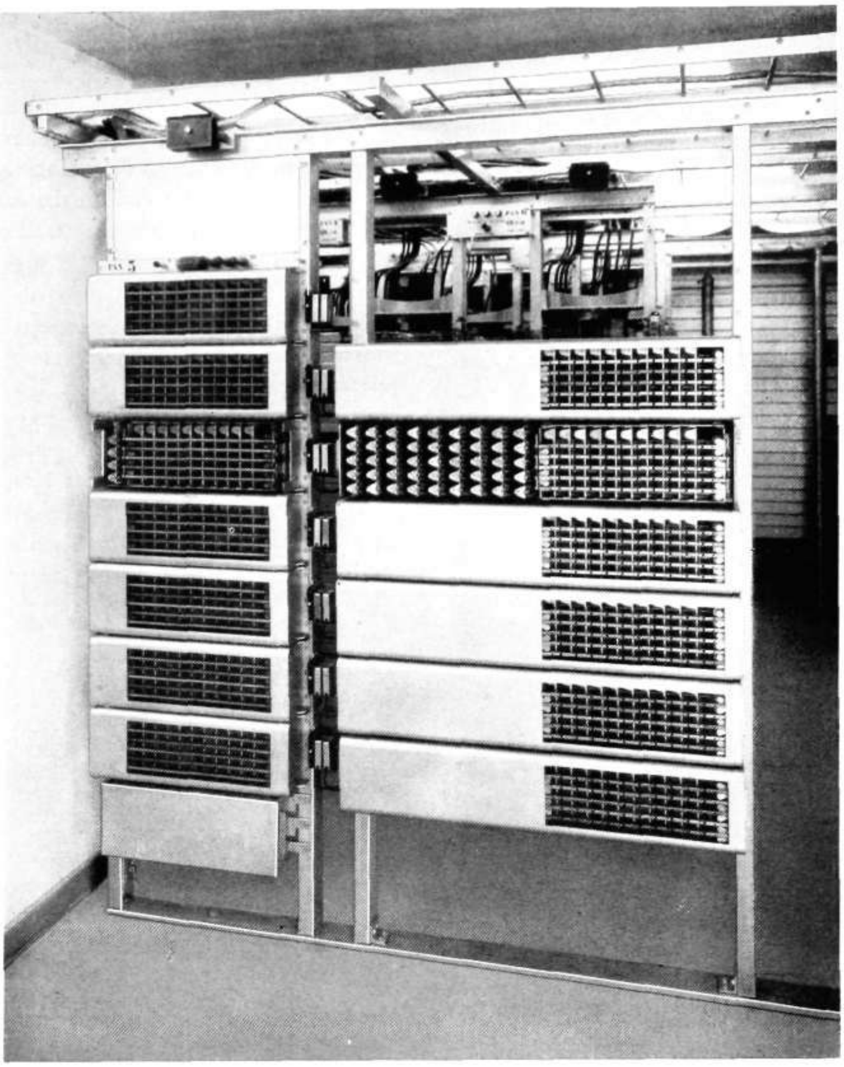


Fig. 2 X 6241
Panel with register and register finder comprising crossbar selectors

inquiry selectors consist of 500-line selectors. In the registers, the machine-driven step-by-step selectors have been replaced by crossbar selectors (one per register), a novelty for the State Railways.

No doubt was felt in the selection of the system and the type of selectors, especially as the 500-line selectors are extremely wellknown for their good operating properties and because the crossbar selector with its simple construction and good contacts had already been used as register selector and had proved capable of bringing down the maintenance costs, already low, of the OS system.

For reasons to be stated later, fixed connections between connecting circuits and registers has not been applied, but register finders, also those of crossbar type, have been inserted between the connecting circuits and registers.

Unlike earlier designs, the line relays are fitted in removable sets with plug-jack fixing, see Fig. 3. Each set comprises 10 line relays *LR* with accessory break relays *BR*. This method of fitting, in itself rather more expensive than fixed fitting formerly employed, has the advantage of saving space and of making the number of line relays easily extensible.

The line relays are constructed for disconnecting function, which means that a faulty extension line or an extension left with an uncompleted call will be re-connected after a certain interval to its own disconnecting relay, while other devices taken up by the faulty call are released.

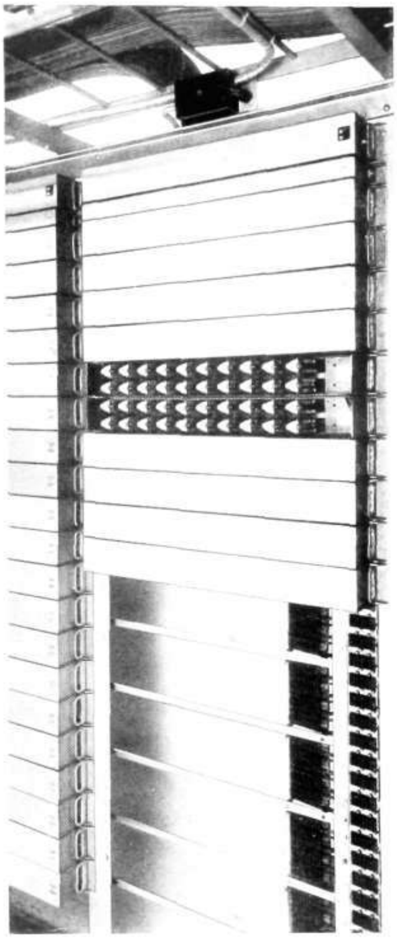


Fig. 3 X 4462

Line relay jack with relay sets inserted

Extent of the Plant

The exchange is designed for building out to four 500-line sections, equivalent to 2000 line relays. The lay-out plan for the P.A.B.X. and the planning of the operator's position multiple have been adapted to this. To begin with, however, equipment has only been installed for 1500 lines. As the automatised section lines are connected to the exchange, a number of the 1500 line relays are taken up by the incoming traffic from these lines.

The rather low ceiling, 2.5 m, in the rack hall necessitated the dividing of the selector racks into parallel-connected racks. Each of these has space for 30 selectors. In a 500 group therefore there is place for 60 finders, 60 group selectors and 60 final selectors. Up to now no more than 40 connecting circuits and 40 final selectors per 500 group have been installed. The group and final selectors are constructed exactly alike and there is facility of group hunting with the final selectors also.

Both selectors and relays are made throughout with twin contacts. Finders and selectors in the 500 group are 3-pole.

The plant comprises panel racks for a total of 5 × 15 incoming *(FIR-C)*, 4 × 15 outgoing *(FUR-C)* and 1 × 15 two-way *(FDR-C)* public exchange lines, but so far the numbers of line equipments fitted are limited to 63, 50 and 10 respectively.

In view of the relatively large number of lines (public exchange lines + connecting circuits for the automatic trunk traffic) on which it must be possible to make inquiry calls, the inquiry links have also been built up of OS selectors. The inquiry link finder *(SF)* is 6-pole and the multiple therefore is limited to 250 lines. The group selector, on the other hand, is 3-pole like that of the connecting circuit.

Inquiry to another extension in the P.A.B.X. is initiated by dialling 0, (one impulse). If it is desired to make inquiry to the operator the figure 8 is dialled. Transfer of the connection is done by putting down the handset after making the inquiry call. If attempt is made to transfer to barred or busy extension, the call is automatically connected over to the operator. For alternate switching over between the original call and the inquired extension the figure 0 is dialled. To get back the original call after uncompleted inquiry call, the handset is put down for a moment.

The manual switchboard comprises 10 operator's positions with a special ordering position and a supervisor's position equipped with various supervisory devices. The switchboard equipment is divided into two groups of five positions per group, one group dealing with public exchange traffic and the other with railway trunk and section line traffic. The switchboard has equipment for 70 public exchange lines, 80 trunk lines and 80 section lines. There are also, of course, the local multiple, equipment for service lines, inquiry lines etc.

Each position comprises 14 cord circuits and 2 local cord circuits. The repeater cord has been entirely dispensed with, as fixed repeaters, individual to each trunk line, are to be introduced. The relay equipments for the positions and the cord circuits are placed in the rack hall in connection with the relay sets for the public exchange lines and the trunk lines. Each position is provided with both dial and keyboard.

The automatic switchboard has a special traffic supervisory position, set up in the rack hall alongside the main distribution frame. The position comprises supervisory strips for all registers, enabling it to be seen how the automatic traffic in the switchboard proceeds. Provision is made for register test by the insertion of line and leakage resistances in the impulsing circuit. For test of the recording and repetition functions of the register the supervisory position is equipped with relay and lamp devices, whose manner of operation corresponds to that of the selectors in a normal connection.

Close to the traffic supervision position there is set up a single position test desk for line testing.

Number System and Register

The switchboard is four-figure and has a maximum local capacity of 3 000 lines in the number series *1000—3999*. As outgoing numbers for the selective calling lines there has been arranged a three-figure series *400—699*. The figure *7* has been reserved as routing figure for any later sub-exchanges. The figure *8* is used for calling the operator at the switchboard or the ordering position and the figure *0* is used for coming out on the public exchange network.

The number series *901—999* comprises exchange numbers for calling other exchanges of the State Railways.

In view of the plans for progressively automatising also the trunk telephone network of the State Railways, so that all new exchanges must be made to allow for this, comprehensive functions have had to be included especially in the registers, though these will not be operative until the automatic trunk traffic is arranged. Thus the local register is capable in conjunction with trunk traffic of registering nine figures. In this case the first figure *(9)* indicates that it is question of outgoing call, the two following figures indicate the wanted exchange and the three or four subsequent figures give the wanted number in that exchange. The remaining two or three figures refer to a telephone post on a selective calling line.

A register includes a crossbar selector and 46 relays. This means that the cost per register will be considerable. Partly with the object of achieving better utilization of the registers, fixed connection between register and connecting circuit has not been employed, but what are called register finders *(RS)* have been introduced as intermediate links. For these crossbar selectors are also used.

Registers and register finders have been fitted alongside each other in double-sided racks, so arranged that the soldering sides of the fixed register finders are open to inspection, whereas the plug-jack fitted registers face each other, see Fig. 2.

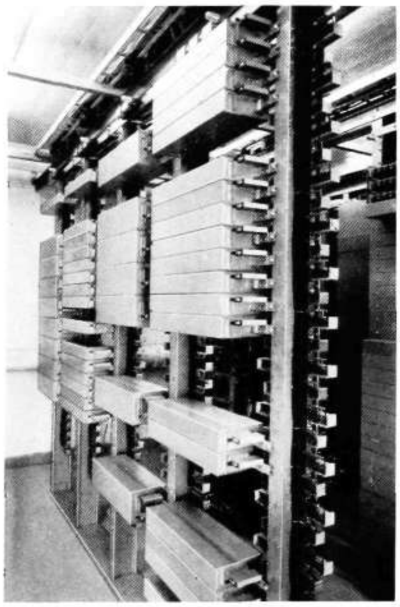


Fig. 4 X 4464

Rack with relay sets for selective calling lines, cord circuit equipments, public exchange lines etc.

Joint Traffic with the Line Telephone Circuits

Of the section network it is mainly the line telephone circuits that are led into the exchange. As stated, these are equipped with LM Ericsson's decentralized selective calling system. In addition to terminal equipment *(SLU)* for each line, there are required two relay equipments *(SFA* and *SFM)* for the connection of the line to the automatic and the manual exchange respectively.

Fig. 6 shows how the line telephone circuits are divided up into groups or routes. Each line group contains the number of circuits necessary for the telephoning requirements of the section in question, and these are made as far as possible uniform in respect of transmission properties and way station equipment.

In the automatic exchange each group has its three-figure group number and each line its individual number.

When dialling from an instrument connected to the automatic exchange to obtain a telephone post on the selective calling line, the five figures of the number (e. g., 40061) are dialled in succession. When three figures have been dialled the line group is fixed, the group selector is set to the group number's position where hunting takes place. The selector then hunts an unoccupied circuit in the group. When one is found and the last figure of the number has

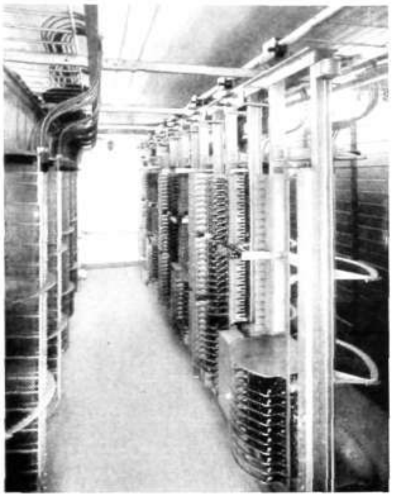


Fig. 5 X 4465
Selector row for 500 numbers with selectors fitted

been dialled, the register transmits to the selective calling line equipment the impulse series corresponding to these last figures and the wanted telephone post is rung.

On call from the selective calling line to or over the automatic exchange a routing figure (usually *o*) is dialled and dialling tone is awaited from the exchange, after which dialling proceeds in the usual manner.

By automatising the line telephone circuits on these principles the scope of the automatic exchange has been extended to cover the telephones on the permanent way sections throughout the district and a first step has been taken towards trunk automatisation.

The most far away selective calling line sections have, as shown by Fig. 6, been drawn to the exchange over through-lines, in many cases phantom circuits. The relay equipments *(SLUV)* for these circuits operate with *A. C.* current and at the transit points between through-line and selective calling section a realy repeater *(IRS)* is required.

The maximum attenuation tolerated on line telephone circuits is 1.2 neper. The considerable length of the lines often makes it necessary to insert repeaters. In such case these are usually placed at the transit points.

Power Plant

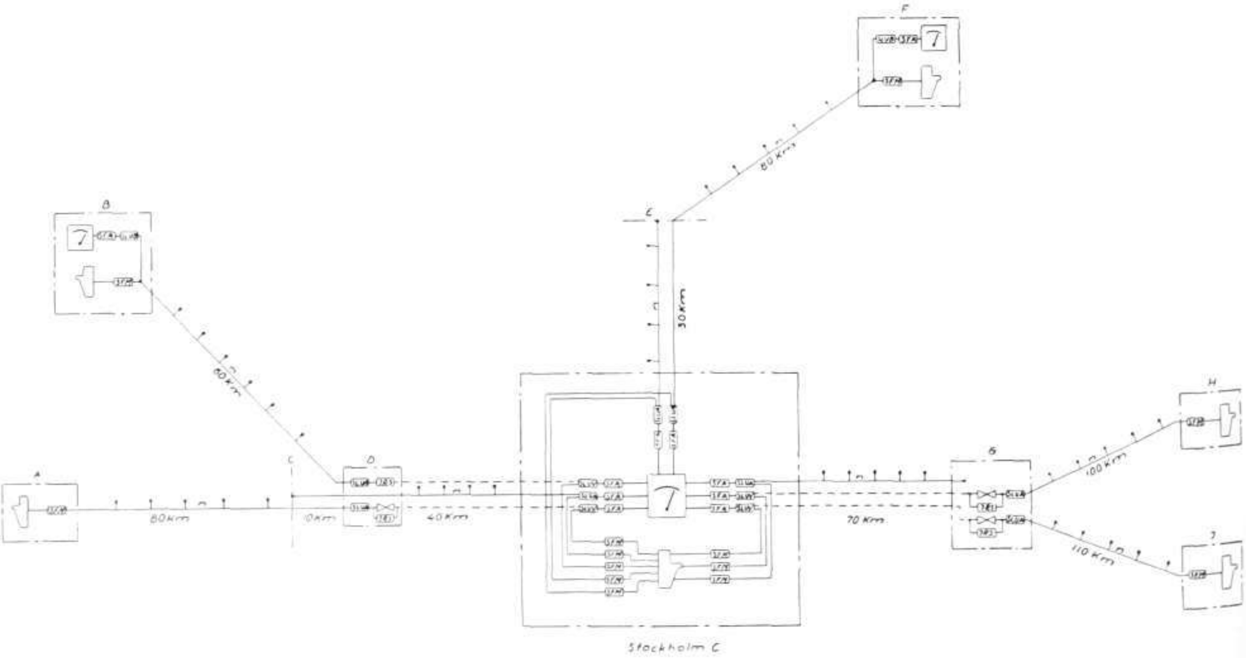
The exchange power plant is supplied with 50-cycle, 3-phase current at 220 V main tension. The power plant consists in the main of two metal rectifiers with transformer and transductor rack, two lead accumulators each for 504 Ah and 24 V, together with an instrument panel with control, supervisory and regulating equipment for rectifiers and batteries. Combined with this instrument panel are a current distribution panel and two panels mounted with power units for terminal equipments of selective calling lines.

The main rectifiers, which are of copper oxide type and arranged for fan cooling, deliver a maximum of 100 A at 24—30 V. They are provided with automatic regulation by means of which the battery tension is maintained constant at ± 1 %, even if the load varies between 5 and 100 A. This regulation is maintained even if the mains tension at the same time varies ± 10 %. In addition there is current regulation limiting the intensity to 100 A.

The rectifiers are designed for normal insertion in the distribution bar system. In this case they may be regulated either automatically or by hand. If, however, the rectifiers are connected to the charging bar system, regulation can only be done by hand.

Fig. 6 X 7423
Network lay-out of the selective calling lines' connection to the private branch exchange at Stockholm Central Station

IRS	impulse repeater
SF	junction equipment
SLUA	terminal equipment for selector line
SLUB	switch-over equipment
SLUV	terminal equipment for A.C.



Automatic Private Branch Exchange Type ALD 20

H MONTELL, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

U.D.C. 621.395.26

In this article a description is given of L M Ericsson's new automatic private branch exchange, type ALD 20, for 20 extensions and 5 public exchange lines and equipped with all modern traffic facilities. The exchange works with rotary step-by-step driven 25-line selectors and consists of a rack on which are fitted all the devices, including distribution. The establishing of internal calls and outgoing public exchange calls is done automatically. The connecting devices of the exchange for internal traffic are not occupied for external calls. Incoming public exchange calls are handled semi-automatically over a switchboard in which each extension has its own ringing key, employed instead of dial in connecting up the extension. Thanks to these keys the work of the operator is facilitated and at the same time the handling of the call is very rapid.

Telefonaktiebolaget LM Ericsson has for a long time had on the market private automatic branch exchanges intended for large and medium-sized plants. The large exchanges, made with 500-line selectors, system OS, are machine-driven and register-controlled. The medium-sized exchanges are made as XY exchanges with step-by-step driven 100-line XY selectors. A feature of this system is that the selectors work in open bare-wire multiples.

The new exchange, which has been given the designation *ALD 20* and is designed for small plants, works with rotary step-by-step driven 25-line selectors, the multiple contacts of which are enclosed in a cylinder thus being effectively protected against dust and dirt. The multiple cable is soldered on tags on the outside of the cylinder.

With the exchange *ALD 20*, as for the OS and XY exchanges, quite ordinary telephone instruments types *DBH*, *DBK* and *DBN* are used as extension instruments. No extra press-button is required on the instruments. The instruments are connected to the exchange over two-wire lines without earth. Consequently the line network will be inexpensive both for installation and maintenance.

This type of exchange has the following important traffic properties:

1. automatic establishment of calls by dialling;
2. priority facility for some extensions;
3. automatic establishment of outgoing exchange line calls by dialling;
4. semi-automatic handling of incoming exchange line calls over an operator's instrument;
5. rapid ringing of extensions for incoming exchange line calls by means of individual ringing keys;
6. facility of putting exchange lines »waiting» when the wanted extension is busy;
7. facility for the operator to break in on calls proceeding;
8. facility for series calls;
9. automatic inquiry facility to all extensions and operator for both incoming and outgoing exchange line traffic;
10. facility of transferring exchange line connections to non-barred or semi-barred extensions, automatically or through the intervention of the operator;

11. night connection;
12. facility in regard to exchange line traffic of dividing extensions into non-barred, semi-barred and barred extensions.

The capacity of the exchange is 20 (21) extensions and a maximum of 5 exchange lines and 4 connecting circuits.

The call numbers of the extensions are: 1, 2, 3, 4, 5, 6, 7, 8, 92, 93, 94, 95, 96, 97, 98, 99, 901, 902, 903, 904, (905).

In cases where the exchange is equipped with not more than 4 exchange lines the number of extensions may be 21. With the putting in of the fifth exchange line, extension 905 drops out.

Incoming exchange line calls are dealt with semi-automatically by an operator serving an operator's set. This instrument has much the same appearance as a telephone instrument type DBH but takes up rather more room, as space must be provided for the press-buttons and lamps required for operating, see Fig. 5. When the operator's instrument is not attended, the exchange lines are night connected to one or more extensions which then handle incoming traffic.

Outgoing exchange line traffic is entirely automatic. The exchange is so constructed that it allows of either one or two outgoing exchange line routings. When only one outgoing routing is present the call number is »0»; when two routings are required the call number for the second routing will be »8». In this latter case the extension with the call number »8» will obviously drop out. Normally the exchanges are supplied connected up for only one outgoing routing. The second routing is obtained by a simple re-switching of the connecting field of the exchange.

The number of exchange lines in either direction can be divided up in any way but naturally the total number cannot exceed the final capacity of the exchange, 5.

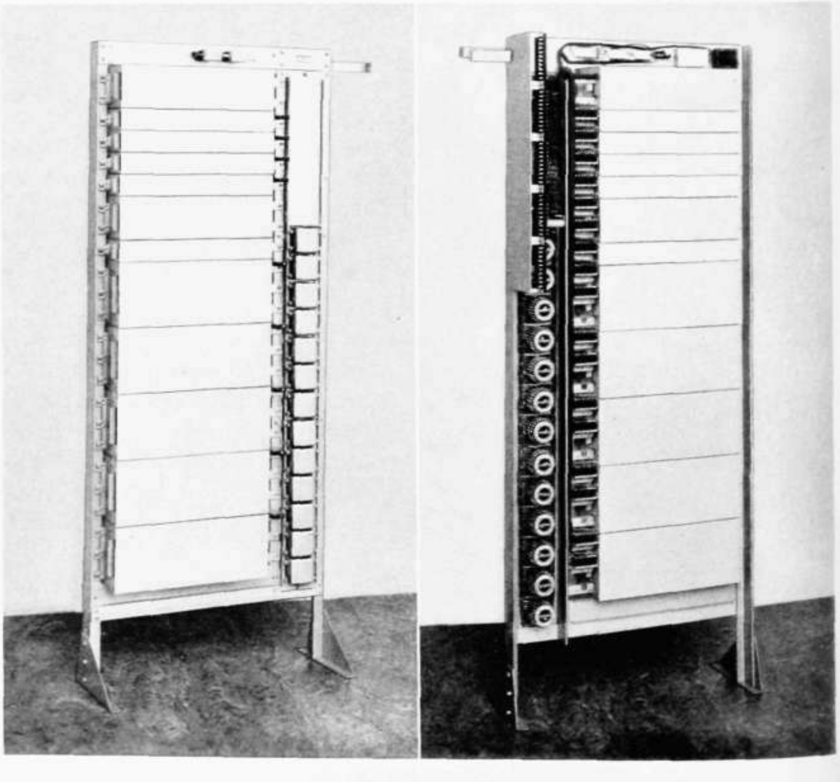
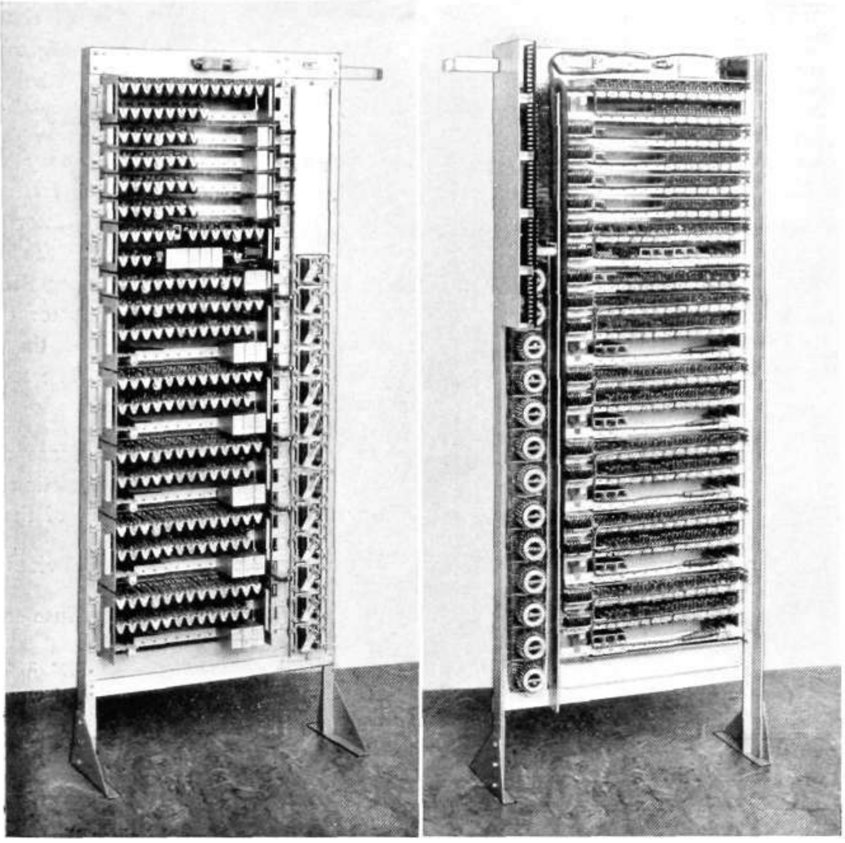


Fig. 1 X 6235

Private branch exchange ALD 20

with 20 extensions, 4 connecting circuits and 5 exchange lines, with protective covers in place; left, front; right, back

Fig. 2 X 6236
Private branch exchange ALD 20
with protective covers removed; left, front; right, back



The connecting devices of the exchange for internal traffic are not occupied either for incoming or outgoing external calls.

The division of the extensions into non-barred, semi-barred and barred extensions is done by connections in the exchange connecting field. The non-barred extensions can receive incoming and themselves establish outgoing exchange line calls, the semi-barred can receive incoming calls but cannot themselves make outgoing exchange line calls and, finally, the barred extensions can neither receive incoming or establish outgoing calls.

In the course of an exchange line call, an extension can by means of the dial make inquiry to another extension or to a subscriber in the public telephone network. After inquiry the extension can transfer the call to any other non-barred or semi-barred extension by replacing the handset. If attempt is made to transfer to a barred extension or to a non-barred or semi-barred extension that has not yet had time to answer, then re-ringing of the inquirer takes place automatically.

Construction

The private branch exchange, Fig. 1, consists of an aluminium enamelled frame screwed together, standing free and of strong construction, with all fixed devices fitted and cabled at the factory. These fixed devices include the line relays and all selectors comprised. Other devices such as all the exchange line equipment etc., consisting of relay sets, form units which are provided with plugs. As the rack is provided with a number of jacks equivalent to the number of relay sets of different kinds with which the exchange can be equipped as a maximum, it is not necessary at the beginning to provide the exchange with a larger number of devices than corresponds to the existing requirements.

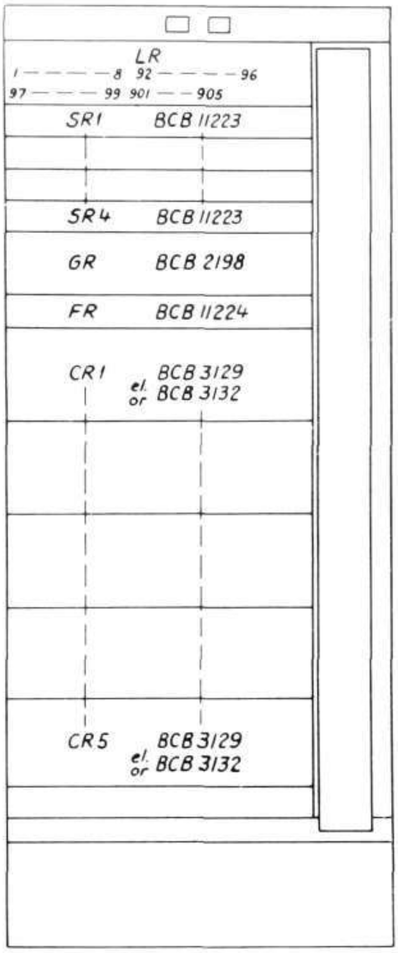


Fig. 3 X 4456

Lay-out plan for private branch exchange, type ALD 20

CR	exchange lines
FR	operator's operating relays
GR	common relay set
LR	line relays
SR	connecting circuits

As traffic grows the number of connecting devices can be progressively increased up to full capacity. Owing to the plug and jack design, this is done in a very simple manner without it being necessary to interfere in any way with the rack or its cabling.

The selectors, consisting of rotary step-by-step driven 25-line selectors, are spring suspended in a selector frame attached to the right-hand side of the rack. The upper part of the selector frame is provided with a terminal block constituting a central place for the connection of the whole exchange. Each selector has a protective hood at the front of the rack covering the selector mechanism. By having the selector contact multiple in a closed cylinder and the mechanism covered by hood, the protection against dust for selectors and contact multiples is complete. The terminal block is protected at the front by a plate.

Both line relay bars and the loose relay sets are provided with sheet metal hoods at front and back as protection against dust. The hoods are one, two or three line according to the size of the relay sets.

The placing of the connecting devices in the rack is shown on Fig. 3.

At the top of the rack are two fuse sets with separate fuses for each relay set.

The dimensions of the exchange are: height 1800 mm, width 734 mm and depth 280 mm. A rack fully fitted weighs 172 kg.

Distribution

The exchange has been equipped with a simple distribution frame, Fig. 4. The exchange side consists of a soldering tag in the terminal block and a wire conductor bar of insulation material that is attached by angle brackets to the inside of the right-hand side of the rack. The line side consists of a distribution plate of iron either screwed on to the outside of the right-hand side of the rack or to the wall against which the exchange stands. This distribution plate is provided with a number of terminal blocks of insulation material having terminal clamps with screws above and soldering strips below. The terminal blocks are provided with wire conductor bars. Incoming cables are connected to the terminal blocks by soldering to the underside.

Jumper wires are soldered to tags in the terminal block of the exchange and are drawn through holes in the wire conductor bar on the exchange side after which they are taken to the line side clamps. The jumper wires are made long enough to allow of connection to any of the line clamps. In jumpering, therefore, the exchange side will always be undisturbed and changing is done on the line side alone.

Operator's instrument

All handling of incoming exchange line calls is done semi-automatically over the operator's instrument. Consequently there is no question of operator's switchboard with cords and subscriber multiple. The appearance of the operator's instrument is shown on Fig. 5. The instrument, in addition to handset and dial, contains separate operating devices for 5 exchange lines, a ringing key for each extension and common operating devices. For each exchange line there is a calling lamp, an answering key, a supervisory lamp and a key for series calls. An extension is rung by pressing the ringing key for that extension and holding it pressed until a lamp in the common equipment shows either that the extension is unoccupied or busy. The dial is used when the operator at the request of an extension has to call a subscriber at an automatic public exchange or when the operator has to ring up an extension over her own extension line.

The operator's instrument is connected to a wall terminal with jacks by a flexible cable provided with plugs.

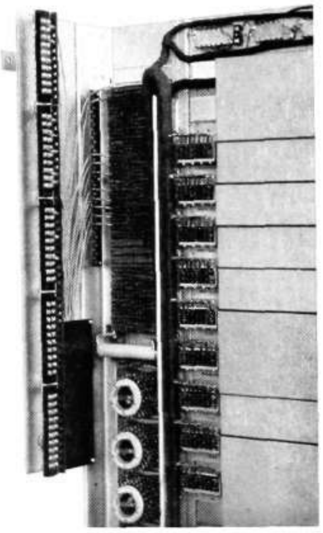


Fig. 4 X 4461
Distribution frame

Operating properties

The exchange is constructed for a normal operating tension of 24 V, but allows of variation in tension from 22 to 28 V. Special arrangements have been made to enable the batteries to stand over-charged while no call is proceeding in the exchange. The over-tension remaining in the battery just after call is made and before the disconnection of the over-charge is eliminated and has no adverse effect on the functioning of the exchange.

The extension line resistance may amount to 500 ohm and leakage resistance may not go below 20000 ohm.

Current consumption amounts to 0.36 A for an internal call and 0.5 A for an exchange line call.

Fitting

As the exchange is delivered ready connected by the factory the work of fitting is confined to setting up the rack, connecting the extension lines and the public exchange lines to the line side for the distribution, jumpering these lines, cabling between the wall terminal of the operator's instrument and the terminal block of the rack and connection of the battery wires.

The detachable connecting devices are delivered separately, carefully packed and are inserted by a simple movement in the rack and fixed by fixing screws. By delivering the relay sets separate from the frame the advantage is gained that disturbances of adjustment due to transport are kept down to a minimum. Consequently there is no need for any lengthy testing before putting the exchange into operation.

Function

The lay-out principle of the private branch exchange will be seen on the skeleton diagram, Fig. 6.

Internal Traffic

When an extension calls, marking takes place in the call finder multiple and at the same time the call finders for all unoccupied cord circuits are started. The call finder that first reaches the marked position in the *AS* multiple stops and its connecting circuit is connected to the calling line. The other *AS* cease hunting unless there are other unanswered calls existing at the same time.

The extension hears dialling tone and dials the wanted number, whereupon the final selector is set to the wanted extension. For multi-figure numbers the setting is done through totalling of the impulses transmitted for the different figures.

If the called extension is unoccupied, periodical ringing signal is sent out and the calling extension hears ringing tone. On answer the ringing is disconnected and the connection is established. The two extensions have common current feed.

Clearing at the end of conversation takes place when both the extensions have replaced there handsets and it is only then that the extension becomes unoccupied and can make fresh call. If a busy extension is called, busy tone is received from the connecting circuit.

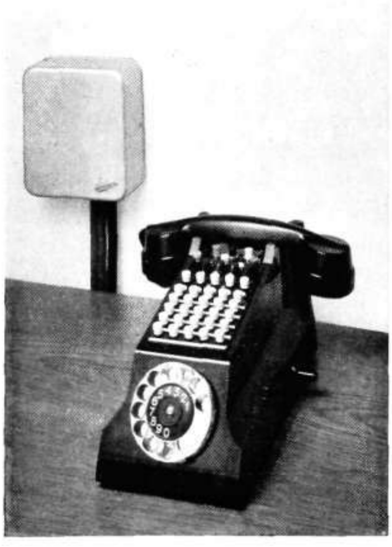


Fig. 5 X 4462
Operator's instrument

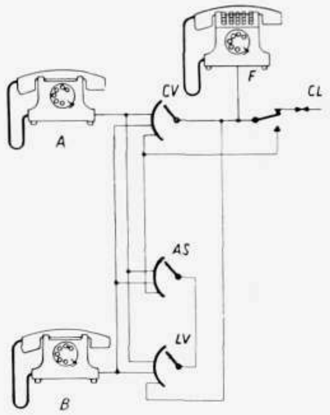


Fig. 6 X 4455

Skeleton diagram of private branch exchange

A, B extensions
AS call finder
CL exchange line
CV exchange line selector
F operator's instrument
LV final selector

Priority

By special marking in the *AS* multiple certain extensions can be given the facility of obtaining connection to a wanted extension even if it is busy. When a priority marked extension rings an extension that is already occupied, connecting in on the call proceeding takes place. A faint warning tone is transmitted to those talking. The priority extension tells those talking to end their conversation and replace their handsets. When this has been done the wanted extension is rung up automatically in the same way as for ordinary call.

External Traffic

The exchange line equipments are arranged for two-way exchange line traffic. Normally they are made for connection to automatic or manual C.B. exchanges, but by a small addition the same relay sets may be used even if the public exchange is of magneto type.

The exchange line equipments are so constructed that clearing takes place when the extension replaces the handset. Because of this, at the end of a call the exchange line must be barred for outgoing traffic long enough for clearing in the public exchange to take place with certainty before the exchange line can again be employed for outgoing call. This is of particular importance when public exchanges are manually operated. This barring is produced by a time device which raises the blockade about 20 s after clearing by an extension.

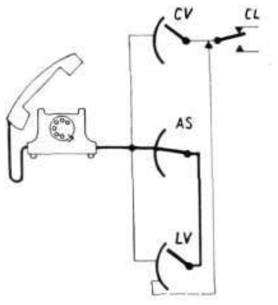
Outgoing Traffic

When the calling extension has received dialling tone from the connecting circuit, the figure for the outgoing route required is dialled. All unoccupied *CV* belonging to the route are then started and the extension is marked in the *CV* multiple over the connecting circuit's call finder *AS*. The *CV* first reaching the marked position stops and at the same time the extension is connected to the exchange line equipment, after which the internal connecting circuit occupied is released and cleared. The other *CV* cease to hunt. Thus the internal connecting circuit is only occupied for a very short time. If the public exchange is automatic, dialling tone is received from it and the wanted number is dialled. If the public exchange is manual, the wanted number is requested from the operator answering. Busy tone is received from the connecting circuit if all exchange lines are busy.

If it is desired to prevent blocking of outgoing exchange line traffic when all connecting circuits are busy, the first connecting circuit is altered by simple re-switching in the connecting field so that it will act as *auxiliary connecting circuit*, the object of which is to deal with outgoing exchange line calls, and it is then only started when the normal connecting circuits are all busy. If an extension that is connected to the auxiliary connecting circuit dials an ordinary extension number, busy tone is received. If, however, the number is dialled for an outgoing routing, unoccupied exchange lines are started in the usual way and the auxiliary connecting circuit is then released.

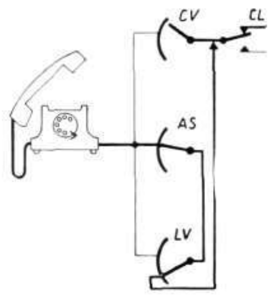
Incoming Traffic

When call comes in on an exchange line, the calling lamp of that line lights up in the operator's instrument. At the same time an audible signal is received. When the operator lifts the handset this audible signal ceases. The answering key for the exchange line is pressed an instant, this connecting the exchange line to the operator's instrument. The calling lamp goes out and the supervisory lamp lights up with blinking light, indicating that this particular exchange line is being attended to. The operator comes into speaking connection with the public exchange subscriber.



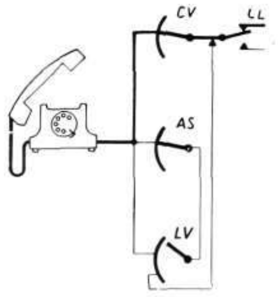
X 4451

The extension calls and is connected to an unoccupied connecting circuit.



X 4450

The extension dials the figure 0 and unoccupied exchange lines are started.



X 4449

The exchange line whose selector CV first reaches the extension is connected; the connecting circuit is disconnected.

Fig. 7
Skeleton diagram for outgoing external traffic

AS	call finder
CL	exchange line
CV	exchange line selector
LV	final selector

Ringing of the extension is done by the operator pressing the ringing key for the wanted extension. By way of this key marking takes place in the *CV* multiple and at the same time *CV* is started and hunts the marked position. A common connecting lamp shows whether the extension is unoccupied or busy. The operator releases the ringing key.

If the extension is *unoccupied* the connecting lamp shines with a fixed light and the extension is rung automatically from the exchange line equipment. The operator informs the calling subscriber that the extension has been rung and leaves the connection by replacing her handset. The supervisory lamp changes over to fixed light until the extension answers, and then goes out.

If the operator first wants to speak with the called extension she should not replace her handset or press any other answering key but instead she presses a special speaking key which switches her speaking set from the exchange side to the extension side. When the extension answers he comes into speaking connection with the operator. As a sign that it is the operator who is ringing the extension over an exchange line, there is transmitted a faint tick-tack tone. The operator by pressing the restoring key can return to speaking connection with the public exchange subscriber. By once again pressing the speaking key she switches herself back to the extension. In this way it is possible for the operator to come alternately into speaking connection with the public exchange subscriber and the extension without one or the other being able to hear what takes place. The operator leaves the connection by replacing her handset, whereupon the operator's instrument is disconnected and the exchange line is connected through to the extension.

If the extension is *busy* the connecting lamp lights up with a blinking light. The operator informs the calling subscriber that the extension is busy with a call and disconnects. If the calling subscriber wishes to wait until the extension is free the operator puts the exchange line at waiting for the extension by replacing her handset. When the extension is free, the exchange line is connected in and ringing takes place automatically. Special arrangements have been made to prevent two or more exchange lines that have been put at waiting for one and the same extension from blocking each other. Only one can be connected in at a time. The others have to wait.

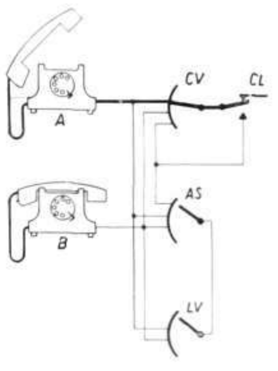
For urgent call the operator can connect herself in on a busy extension. This is done by pressing a listening-in key common to all exchange lines. A tick-tack tone is transmitted and indicates to those speaking that the operator is connecting herself in on the call. The operator offers the exchange line call and if this is accepted she presses a common cut-off key, keeping the listening-in key pressed. The call proceeding is broken and the wanted extension is connected to the exchange line. All calls, both exchange line and internal, can be broken.

If an exchange line is cut off it is not entirely disconnected but the operator is called again and she can connect a disconnected exchange line to another extension or put it at waiting for the extension from which it was broken.

If the operator has put an exchange line at waiting for an extension and this extension later does not answer, the operator can connect in the exchange line again by pressing the answering key. She then announces that the wanted extension does not answer. After that she may disconnect the call, let the calling subscriber remain at waiting or connect him to another extension.

When an extension has answered and the operator has once left the connection, she cannot without intervention of the extension again connect in the exchange line to the operator's instrument.

It is not necessary for the operator to replace the handset after each connection. The operator may instead press the answering key of another exchange line. The exchange line connected to the operator's instrument will then automatically be put at waiting, the new line being connected in to be dealt with.



X 4453

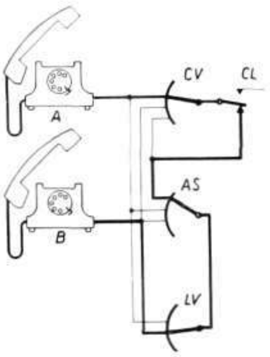
The extension A has an external call over the selector CV on exchange line CL

Inquiry Calls

An extension in conversation with an exchange line can by dialling a single impulse make inquiry without clearing signal going out to the public exchange. By way of the exchange line relay set the extension is switched over from the exchange line to an inquiry line which is connected to a local connecting circuit. The extension dials the wanted number and ringing tone takes place as for an ordinary local call. At the conclusion of the inquiry, the extension returns to the exchange line by once again dialling one impulse and the speaking connection is re-established with the public exchange subscriber. If the inquired extension remains with handset lifted the connecting circuit is not disconnected and the inquirer may alternate as often as he likes between the exchange line and the inquired extension by repeatedly dialling one impulse. When the inquired extension replaces the handset and the inquirer returns to the exchange line, the inquiry circuit is disconnected.

Inquiry can be made to all extensions whether they are non-barred, semi-barred or barred.

Inquiry can also be made over another exchange line to a public exchange subscriber. In this case, however, it is not possible to alternate any number of times between the first exchange line and that inquired of, as the exchange line over which the inquiry is made is immediately disconnected on return.
Priority extensions retain their priority for inquiry also. Non-priority extensions may with the aid of the operator become priority for inquiry call.



X 4452

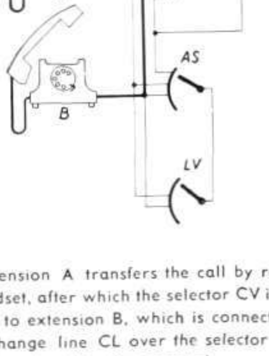
The extension A makes inquiry to extension B and the exchange line CL is disconnected from the extension A, speaking connection between the extensions being maintained over a connecting circuit (call finder AS and final selector LV).

Transfer

An exchange line call may be automatically transferred to a non-barred or semi-barred extension. This is done by first making inquiry. When the inquired extension has answered and remains with raised handset the inquirer replaces his handset. It is all the same if the inquirer last had speaking connection with the exchange line or the inquired extension. The exchange line selector is moved over to the inquired extension's position in the multiple, after which the internal connecting circuit is disconnected. Transfer may be repeated any number of times.

If attempt is made at transfer to a barred extension or after the inquired extension has replaced his handset, the inquirer is rung up again automatically.

Transfer cannot be done to another exchange line.



X 4454

The extension A transfers the call by replacing the handset, after which the selector CV is switched over to extension B, which is connected in to the exchange line CL over the selector CV, the connecting circuit is disconnected.

Fig. 8
Skeleton diagram for inquiry and transfer

A, B	extensions
AS	call finder
CL	exchange line
CV	exchange line selector
LV	final selector

Re-calling the Operator

If an extension occupied with exchange line call wishes to call the attention of the operator this is done by re-calling. The extension dials two impulses. The exchange line call lamp lights up without the speaking connection being broken. The operator answers the call by pressing the answering key and connects herself in on the extension to receive instructions. It is not necessary for the extension to await the operator's answer, but he can replace the handset as soon as re-call is made. The extension is disconnected and the operator has to attend to the call as if it were an ordinary incoming call.

Series Call

If a public exchange subscriber wants to talk with several extensions he informs the operator, who turns the series call knob of the exchange line. The exchange line is not disconnected when the extension replaces the handset, but the calling lamp lights up instead. The operator takes in the exchange line to her instrument and passes the call on to the next extension. When this has been done to the last extension the series call knob is restored.

Night Connection

All exchange lines may be night connected to separate extensions. It is also possible to night connect several or all exchange lines to one and the same extension if this is considered desirable.

The operator prepares night connection by throwing a common night connection switch. If she neglects this, night connection comes into operation automatically if an incoming exchange line call is not answered within a certain time.

When call comes in on a night connected exchange line, the extension is rung automatically. If the extension is busy, there is transmitted a faint warning signal to announce the call that has come in. The call in progress should be terminated as soon as possible, after which the extension is rung up by the exchange line. If the extension does not answer a call, clearing of the exchange line equipment takes place a certain time after the calling signals from the public exchange have ceased.

A night connected extension may pass on the call to another extension by transfer. When night connected, an extension has priority even if normally it does not enjoy this privilege.

ALD 10 — a New Automatic Private Switchboard

H MONTELL, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

U.D.C. 621.395.24

L M Ericsson's new automatic private switchboard for up to 22 extensions and with three or four call facilities is described in this article.

The switchboard is chiefly intended for use in small offices and factories, in large residences etc. In working out the switchboard, particular attention has been devoted to efforts to produce a type of switchboard requiring a minimum of maintenance and operating reliably even with great variations in the working tension. The current supply of the switchboard may consist either of a charging unit with booster battery or of a battery eliminator.

For a long time LM Ericsson has been making for small automatic private telephone plants a telephone switchboard with the designation OL 35. Owing to its good working properties this switchboard has gained great popularity with our customers and more than a thousand of the type are at present in operation.

Nevertheless telephone practice has in recent times produced many new connecting components, permitting of the production of automatic switchboards which, with a minimum of maintenance, display even better operating and traffic properties than the types previously developed. Telefonaktiebolaget LM Ericsson has therefore produced a new type of switchboard for the same number of extensions and intended to cover the same range of employment as the switchboard type OL 35.

On working out this new switchboard, which has been given the designation *ALD 10*, the special aim has been to arrive at a cheap and simple design, without in any way neglecting the demands imposed on a first-class automatic telephone switchboard in respect of operating properties, mounting and maintenance.

ALD 10 is adapted for internal telephone service in offices, warehouses, factories, large residences etc., where there is wanted a plant always ready for use 24 hours a day. The switchboard is made for 22 extensions and four simultaneous calls. There is a variant allowing of three calls at a time. The calls are secret.

With the ALD 10 switchboard, as with LM Ericsson's other automatic telephone switchboards on OS and XY systems, quite ordinary telephone instruments types *DBH*, *DBK* and *DBN* are used as extension instruments. The telephone instruments are connected to the automatic switchboard over two-wire lines. The line network, therefore, is inexpensive both in installing and in maintenance.

The call numbers for the extensions are: *1, 2, 3, 4, 5, 6, 7, 8, 91, 92, 93, 94, 95, 96, 97, 98, 99, 901, 902, 903, 904, 905.*

Construction

The switchboard, see Fig. 1, is made for wall mounting and consists of a bedplate of wood on which a swing-out relay and selector frame is attached. A sheet-metal hood, fitting over the relay and selector frame, protects the switchboard against dust and mechanical stress. The hood is fixed in position by four undetachable screws. The hood and the other parts of the switchboard are in aluminium finish, giving the switchboard an attractive appearance, going well with modern office fittings.

The main switching components making up the switchboard consist of single-coil relays, provided with twin contacts, and rotary step-by-step driven 25-line selectors, type RVE. Both relays and selectors are fitted on iron bars, these in turn being screwed vertically on to a welded angle-iron frame. The relays and selectors are attached by cables to each other. By fitting the relays in lying down position the advantage is gained that dust is not deposited on the relays to cause contact fault.

The selectors are suspended on springs individually, which ensures silent running. Each selector is provided with a protective hood at the front, this covering the actual selector mechanism. The contact multiple of the selector is in a closed cylinder and as the mechanism is protected by the hood, both selector mechanism and contact multiple are entirely dust-proof.

The bedplate is provided with two vertically fitted iron brackets serving as fixing iron for relay and selector frame. This frame is attached on hinges to the left-hand bracket. Normally the frame is swung in against the bedplate and fastened in position by two box-hooks, gripping the right-hand vertical bracket. On loosening the hooks the frame may be swung out at right angles to the bedplate. In this way both the back and the bedplate are easily accessible, see Fig. 2.

Two rows of terminal strips, with screws in front and soldering tags at the rear, are screwed on to the bedplate. The line relay wires of the switchboard are soldered on to the left-hand terminal strip. Incoming line cables are connected to the right-hand strip by soldering at the rear. Connection between the two strips is done by loose jumper wires. It is thus possible in simple manner to connect any of the instruments to any of the switchboard numbers. By always threading the jumper wires through the wire guide rings the wires are kept in good order.

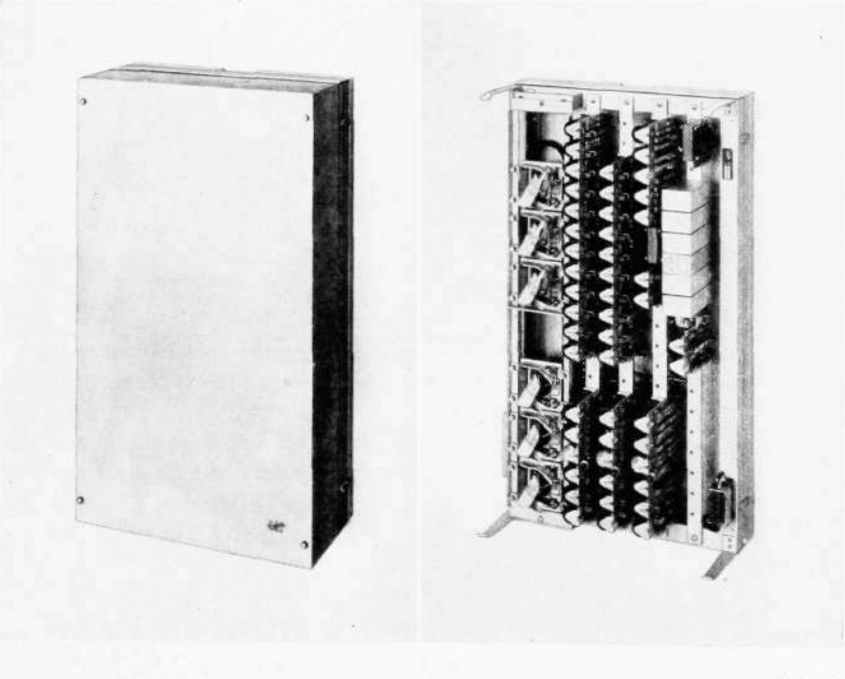


Fig. 1 X 6239

Private switchboard. type ALD 10

for 22 extensions and 3 calls at a time, on right with cover removed

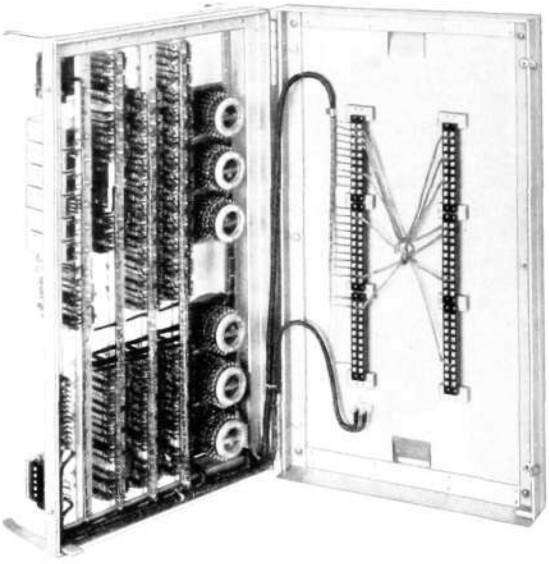


Fig. 2 X 6240

Private switchboard 1001

without cover and with relay and selector frame swung out

There are special slots at the top and bottom of the bedplate to enable incoming line cables and battery wires conveniently to be led into the switchboard.

Operating Properties

The normal working tension of ALD 10 is 24 V, but variation in tension between 22 and 28 V is permissible. The current supply plant of the switchboard consists either of a charging unit with booster battery or a battery eliminator for connection to the electric distribution network.

Special arrangements have been made to permit of the batteries, when used for current supply, standing under over-charge during times when no call is proceeding in the switchboard. The over-tension remaining in the battery just after call is made and before disconnection of the over-charge is eliminated and has no adverse effect on the switchboard's operation.

The extension line resistance may amount to 500 ohm, corresponding to a distance between instrument and switchboard of more than 2.5 km, if normal 0.5 mm telephone cable is used. In practice it is hardly likely that any greater distance would arise with telephone plants such as this type of switchboard is intended to serve. The leakage resistance must not be below 20000 ohm.

The current consumption during a call amounts to 0.4 A.

Fitting

As the switchboard is delivered ready connected from the factory, the work of fitting on the spot is confined to attaching the switchboard to the wall and connecting up the extension lines and the current supply plant.

Setting up the switchboard is a simple matter, the left-hand terminal strip and the battery terminal block being removed from the bedplate, after which the relay frame is detached from the left-hand fixing iron. The bedplate is now easy to handle and is hung up in place with the aid of a single-point suspension device, to be found at the back of the bedplate. After straightening and marking, the bedplate is attached by bolts to the wall, after which the relay frame is screwed in place, followed by the terminal strip and the battery terminal block.

As the switchboard is well guarded against dust, has comparatively noiseless running and takes up little space, there is no need to fit it in a special cabinet or switchboard room, but it can quite well be set up on the wall of any office room or in a corridor.

Operation

The principle of the building up of ALD 10 is extremely simple, as may be seen from Fig. 3. Each connecting circuit consists of two 25-line selectors, one serving as call finder *(AS)* and the other as final selector *(LV)*, and a relay set *(SNR)*. In addition the switchboard contains a line relay *(LR)* for each extension and a relay set *(GR)* common to the whole switchboard.

Call from Ordinary Extension

When an extension makes a call, this is marked in the call finder multiple. All unoccupied connecting circuit finders start up. The connecting circuit whose call finder first reaches the marked position in the multiple is connected immediately the call finder stops at that position. The other finders cease to hunt.

The extension hears dialling tone and dials the wanted number, on which the final selector is stepped forward to the wanted extension. With multi-figure numbering the setting is done by totalling the impulses transmitted for the different figures.

If the extension rung is unoccupied, periodical ringing signal is sent out and the calling extension hears ringing signal in his receiver. When the called subscriber answers, the ringing is disconnected and speaking connection is established. Restoration of the connecting devices at the close of the call takes place when both extensions have replaced their handsets.

If a busy extension is called, busy tone is received from the connecting circuit, which is disconnected when the handset is replaced.

Call from Priority Extension

The switchboard is provided with devices giving facility to any three extensions to be connected in on any desired extension, even though a call may be proceeding. These three extensions therefore have priority over the other extensions and are called priority extensions.

If it is desired to have the switchboard extended for priority facilities the connecting circuit equipment must be supplemented by one relay. The extensions that are to have priority are given a special marking in the call finder multiple. When a priority extension calls an extension already busy, connection

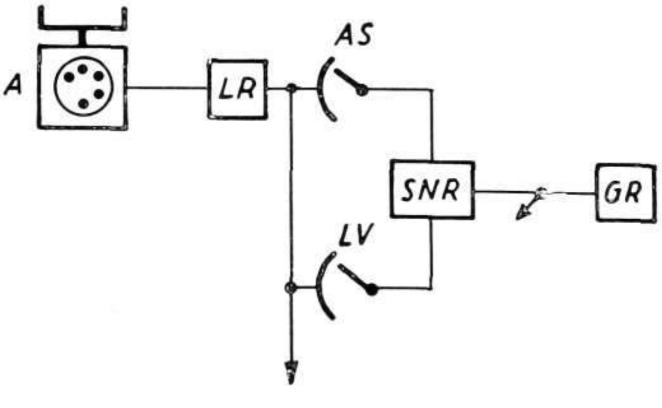


Fig. 3 X 6237

Connecting diagram for private switchboard ALD 10

A	extension
AS	call finder
GR	common relay set
LR	line relay
LV	final selector
SNR	*connecting circuit*

to the call in progress takes place direct, while at the same time a faint busy tone indicates to the talkers that a third person has been connected in. The priority extension may then either give a brief communication to the called extension and then leave the connection by replacing the handset or else call on the speakers to terminate their conversation while he remains with handset raised. In the latter case the extension first called is rung automatically and the conversation may continue undisturbed. Restoration of the connecting devices at the close of the call takes place in the same way as for call from an ordinary extension.

Switchboard Types

The following catalogue types of switchboards are made:

catalogue type	capacity		priority relays	weight kg	measurements		
	number of extensions	number of call facilities			height mm	width mm	depth mm
ALD 1001	22	3	not present	47	714	415	220
ALD 1002	22	4	» »	52	»	»	»
ALD 10011	22	3	present	48	»	»	»
ALD 10021	22	4	»	53	»	»	»

Switchboard types ALD 1001 and ALD 1002, which are without priority relays, are cabled in such a way that without difficulty they may be supplemented by these relays if required. They then become types ALD 10011 and ALD 10021.

Alternating Current Potentiometer

S HOLMQVIST, LM ERICSSONS MÄTINSTRUMENT AB, ULVSUNDA

U.D.C. 621.317.7

The alternating current potentiometer, patented in Sweden and other countries, was developed by the author at Chalmers University of Technology in Gothenburg and is now being manufactured by L M Ericssons Mätinstrument AB (Ermi). It differs in principle from earlier A. C. potentiometers, in which a direct comparison between the wanted A. C. voltage and a known A. C. voltage was made. For such comparison the two voltages must be the same in respect of frequency, shape of curve and phase angle. In practice it is not possible to attain this, if any great degree of accuracy is desired.

With the new principle, the wanted A. C. values, current, voltage or active power are transformed into direct current voltages, which are measured with D. C. potentiometers. From these measurements it is then possible to compute the wanted A. C. values. The transforming is done by thermic means, so that in principle the value will be unaffected by frequency, shape of curve or phase angle. Naturally, for practical reasons, there arises a limitation of the independence of frequency owing to the angle of error of the resistances and capacitative leakances. The apparatus described is intended mainly for main frequencies.

Accurate measurement of D.C. voltages and D.C. currents and thereby also powers are carried out on the potentiometer method, the wanted voltage or voltage drop over a standard resistance being compared with a known voltage. For alternating current corresponding methods cannot be employed directly owing to the impossibility of obtaining an accurately known A.C. voltage with the same frequency, shape of curve and phase angle as that sought.

In the measurement method described below, the thermic action of the current is utilized to convert the A.C. current figures into D.C. values that can be accurately measured by a D.C. potentiometer. The measurement values for current, voltage and active power are in principle obtained entirely in the effective values and they are independent of the A.C. current's frequency, shape of curve and phase shift. The method is based on the compensating and zero method, so that the measurement accuracy is great. As the measurement result for current, voltage and active power is determined by the standard cell's voltage and by the value of the ohmic resistance, the measurement can in principle be carried out as accurately as with pure D.C. voltage.

Measurement Principle

In Fig. 1, r designates a pure resistance that is traversed by three currents I_1, i_1 and i_2, where I_1 is a direct current and i_1 and i_2 alternating currents of the same frequency (momentary value).

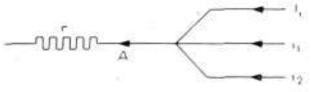


Fig. 1 X 4457

Skeleton diagram for a potentiometer where r is traversed by three currents: the D. C. current I_1 and the A. C. currents i_1 and i_2 these currents together giving the resultant current A

Designating by A the value of the resultant current for the three currents I_1, i_1 and i_2 then

$$A^2 = \frac{1}{T}\int_0^T (I_1 + i_1 + i_2)^2 \, dt$$

If one of the A.C. currents, e. g., i_2, is phase shifted 180° in relation to the other, i. e., the direction of current is reversed, the sign for i_2 in the integral

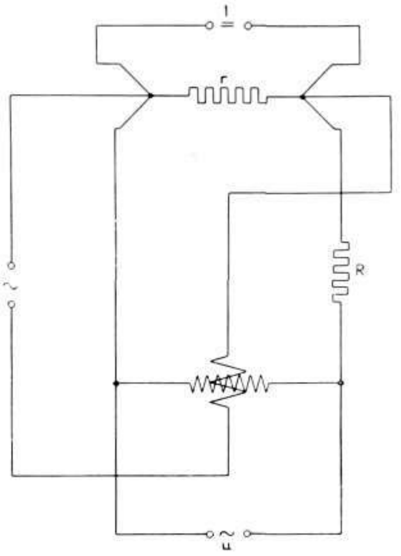


Fig. 2 X 4458
Connecting principle for checking wattmeter

will be changed to minus. The value for the D.C. current will now be given such a value, I_2, that the same resultant current A is still obtained. In this case, therefore,

$$A^2 = \frac{1}{T}\int_0^T (I_2 + i_1 - i_2)^2\,dt$$

In these integrals I_1 and I_2 are constant, whereas i_1 and i_2 are functions of the time. If the integrals are made equal and developed and simplified, we get

$$\frac{I_2^2 - I_1^2}{4} = \frac{1}{T}\int_0^T i_1 \cdot i_2\,dt$$

If the voltage drop over r corresponding to the current i_2, that is $u_2 = i_2 \cdot r$, is inserted, then

$$\frac{r}{4}(I_2^2 - I_1^2) = \frac{1}{T}\int_0^T i_1\,u_2\,dt$$

The term on the right is the general expression for the A.C. power P_r developed in r

$$P_r = \frac{r}{4}(I_2^2 - I_1^2)$$

To illustrate the employment, there is shown in Fig. 2 the connecting principle for the checking of a wattmeter. The voltage terminals are fed with A.C. voltage u and the current terminals with A.C. current i (momentary value). The resistance r as in the foregoing is fed partly by the current i and voltage u over the series resistance R and partly by the D.C. I.

The A.C. power that the wattmeter should indicate is

$$P = \frac{1}{T}\int_0^T u \cdot i\,dt$$

In the resistance r there is developed the A.C. power

$$P_r = \frac{1}{T}\int_0^T i \cdot r \cdot \frac{u}{r+R}\,dt$$

$$P_r = \frac{r}{r+R}\cdot\frac{1}{T}\int_0^T i \cdot u\,dt = \frac{r}{r+R}\cdot P$$

According to the foregoing

$$P_r = \frac{r}{4}(I_2^2 - I_1^2)$$

$$\therefore P = \frac{r+R}{4}(I_2^2 - I_1^2)$$

Consequently by measuring the D.C. currents I_1 and I_2 it is possible to compute the value that the wattmeter should indicate and thereby determine its correction.

The conditions for power measurement on the principles given are:

1) that a known resistance r can be fed with three currents, one D.C. and two A.C. independent of each other, which are proportional to the measuring current and the measuring voltage respectively

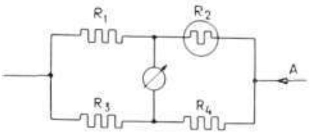


Fig. 3 X 6229
Bridge coupling with a current sensitive resistance R_2

2) that the three currents' resultant current can be regulated to the same value when one of the two A.C. currents is phase shifted 180°. Regulating is done by altering the D.C. current's value
3) that the value of the two D.C. currents required for compensating at the two measurement stages may be measured with sufficient accuracy.

The Current Sensitive Device

To indicate the resultant current there is employed a current sensitive resistance in bridge coupling as per Fig. 3. The resistance R_2 consists of a specially treated wire, inserted in an evacuated glass balloon. When current is led through the resistance the resistance alters and for a certain, similarly determined current, the resistance takes on such a value that the bridge is in equilibrium, causing the galvanometer to point to zero.

Through the current sensitive resistance R_2 there flows a certain fraction of the three currents that together make up the resultant current A. The heating and therefore the resistance alteration will be governed by A^2. Thus the bridge is in equilibrium for a certain determined value of A. The D.C. component in the resultant current causes, on unbalance in the bridge, a deflection on the D.C. galvanometer, which is thus employed as a zero galvanometer.

The demand that must be put on the resistance R_2 is that this must not alter its thermic properties during the minute required for a normal measurement. By appropriate fitting and insulation this demand can easily be met. In practice certain advantages are gained if the variations in the resistance for a long period are small, and therefore the wire in the current sensitive resistance should be carefully aged.

Connecting Diagram

The method employed to deliver to the bridge coupling the three currents may be seen on Fig. 4. The bridge coupling R_1, R_2, R_3 and R_4 constitute the one resistance in a second bridge where the other resistances are designated by R_5, R_6 and R_7. This resistance combination R_1—R_7 is included in a third bridge coupling, where the other resistances consist of R_8, R_9 and R_{10}. With the correct current through the current sensitive resistance R_2, all three bridges are in equilibrium.

A certain fraction of the measurement current I traverses the bridge R_1—R_4. The current that is caused by the measurement voltage U and by the D.C. source L will in the same way with a certain fixed fraction traverse the bridge R_1—R_4. None of the three currents can be affected by the others, as the feeding is always done at points with the same potential as regards the two others.

The second condition, viz: that it shall be possible to regulate the resultant current to the same value when one of the A.C. currents is phase-shifted 180° is fulfilled with the zero galvanometer giving no deflection. To produce phase shifting, one of the A.C. currents may be reversed by a current reverser at the terminals I or U in Fig. 4. By regulating the magnitude of the D.C. current in the two cases the resultant current is regulated to the correct value by observation of the zero galvanometer. A condition is naturally that the resultant value of the two A.C. currents alone does not exceed the selected total resultant current. With small values for the D.C. current this will be small through the galvanometer and the accuracy of the regulating will be low. With small A.C. current values the thermic action of the current on R_2 will be small, so that in this case too the regulating will not be sharp. The best value is obtained when the D.C. current is of the same order of magnitude as the resultant of the two A.C. currents. This means that the measurement range on the A.C.

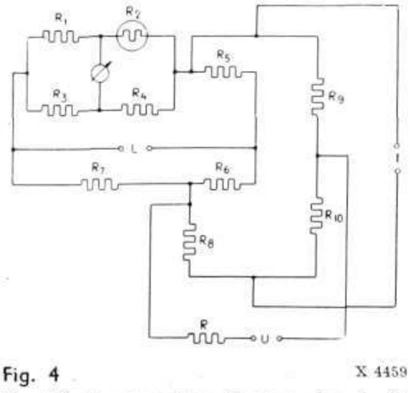


Fig. 4 X 4459
Simplified connecting diagram for A. C. current potentiometer

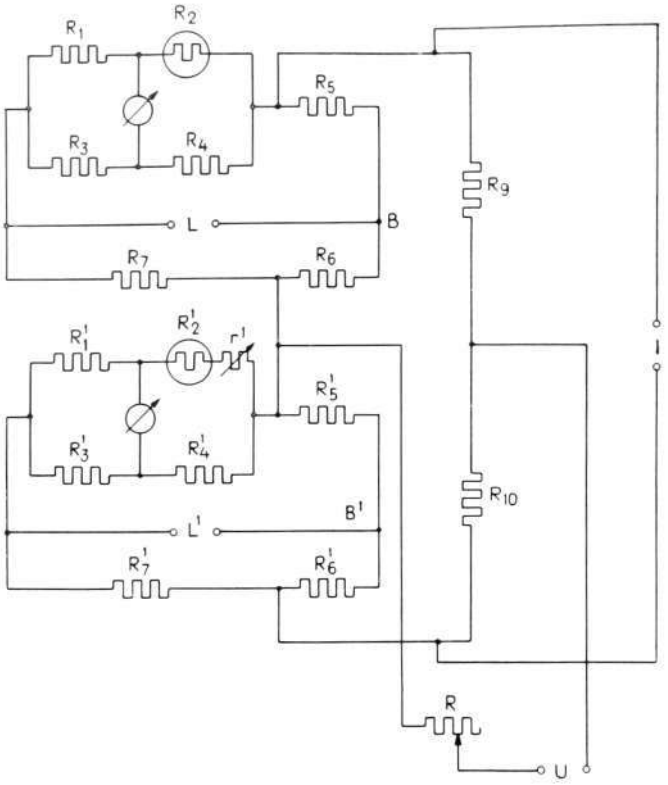


Fig. 5 X 6232
Skeleton diagram of the potentiometer and two current sensitive resistances

current side will be relatively small. It is possible to increase the measurement range by means of shunts and series resistances. To ensure adequate adjustment accuracy, the step between the two measurement ranges should not exceed 1 : 2.

With measurement by this method, as shown in Fig. 4, great demands are put on the constancy of the A.C. sources. This is because the two measurements must be carried out by regulating the magnitude of the D.C. current on reversing, e. g. of the alternating current I. During the time taken up by the measurement the alternating currents must not alter in magnitude. It is therefore desirable that the two measurements should be executed as rapidly as possible without time being wasted in the moving of knobs and switches.

This requirement is fulfilled by executing the apparatus in conformity with the diagram shown in Fig. 5. Here the resistance R_8 of Fig. 4 is replaced by a bridge coupling $R_1{}^1$—$R_7{}^1$. In this there is included also a current sensitive resistance $R_2{}^1$. As may be seen from the diagram, the current from the U terminals is reversed in the two resistances R_2 and $R_2{}^1$ in relation to the current from the I terminals. There is therefore required no switching over of the measurement current at the two measurement stages, but the direct current in each of the circuits can in principle be set at the same time. For practical reasons the same zero galvanometer is employed, this being connected alternately into the two circuits by a switch.

The condition for the employment of this method, however, is that the two bridge circuits are exactly alike and installed for the same resultant current. This check can most simply be made by the zero galvanometer being connected to the points B and B_1 in Fig. 5. If the voltage here is zero and the two bridges at the same time are in equilibrium then the two current sensitive resistances R_2 and $R_2{}^1$ must be traversed by the same current. Any changes in one of the resistances R_2 and $R_2{}^1$ may be compensated by the adjustment resistance r^1. When making this check no alternating current should be connected to the instrument.

The third condition for accurate measurement with the instrument is that the D.C. currents required for the compensation may be measured with great accuracy. It is therefore necessary to employ a D.C. potentiometer. As the resistances in the two bridge circuits have the same resistance for correct resultant current, the voltage fall over the L and L^1 terminals can be directly measured by the potentiometer. Two different sized voltages must be measured and the potentiometer therefore should be so constructed that these may be determined rapidly. A double potentiometer is therefore the most suitable. (Cf. Ericsson Review No 1, 1946)

Power Measurements

According to the above, the power measured by the instrument as per Fig. 2 is

$$P = I \cdot U \cos \varphi = \frac{r + R}{4} (I_2^2 — I_1^2.$$

where $r + R$ is the resistance between the terminals.

For computation of the corresponding power according to Fig. 5, the current branching in the different bridges must be taken into account. By suitable choice of the resistances it is possible, for example, for 0.3 of the A.C. currents delivered to the U and I terminals and 0.4 of the D.C. currents conveyed to the L and L^1 terminals to be fed to the current sensitive resistances R_2 and R_2^1 respectively. Then

$$0{,}3 \cdot I\ 0{,}3\ V \cdot \cos \varphi = \frac{r + R}{4} [(0{,}4\ I_2)^2 — (0{,}4\ I_2)^2]$$

or

$$P = \frac{r + R}{4} \cdot \frac{16}{9} (I_2^2 — I_1^2)$$

The resistance between the L terminals may be taken at 200 : 3 ohm. If U_1 and U_2 are used to designate the voltage drop over the L terminals corresponding to I_1 and I_2, there is obtained

$$U_1 = \frac{200}{3} \cdot I_1$$

and

$$U_2 = \frac{200}{3} \cdot I_2$$

The value for r may be selected as 100 ohm and the factor $R + 100$ may be replaced by 100 K. Then there is obtained after simplifying

$$P = 0.01 \cdot K\ (U_2^2 — U_1^2)$$

With a series resistance $R = 0$ the value for $K = 1$ and the resistance between the U terminals is 100 ohm. If 1 V is connected the current will be 10 mA in the outer circuit. Thus there goes through the resistance R_2 or R_2^1 the current 3 mA. To obtain the same current from the I terminals these must be fed with 10 mA or 0.01 A. The factor 0.01 in the preceding equation thus gives added current reckoned in amperes.

To augment the measurement range, the I terminals may be provided with shunts, selected so that 10 mA is fed into the measurement device with mark current. If the shunt mark current is designated by C then there holds good generally

$$P = C \cdot K \cdot (U_2^2 — U_1^2)\ \text{W}$$

The above-described form of execution with different current and voltage circuits may conveniently be employed for checking power and energy meters.

The device may also be employed for direct power measurement of an instrument. The connecting diagram is shown in Fig. 6. In this, which largely agrees

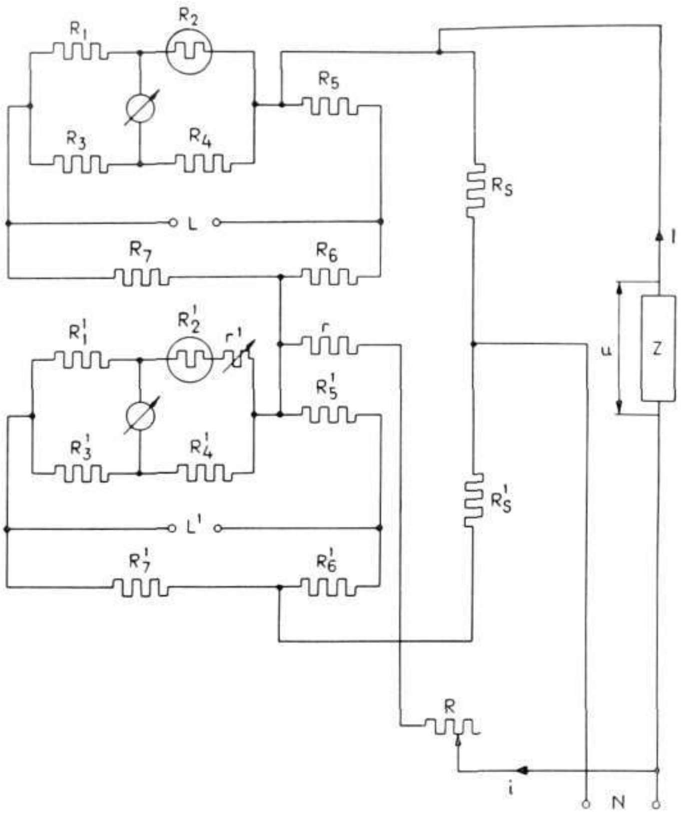


Fig. 6 X 6233

Connecting diagram for direct power measurement on an object Z

i	current in the voltage circuit
I	current through the object of measurement Z
L	source of D.C. current
N	source of A.C. current
r	resistance
R	resistance
u	voltage over the object of measurement Z

with Fig. 5. Z represents the instrument of which the power consumption is to be determined. The source of current is represented on the figure as N. If the voltage over Z is designated by U and the current through Z by I then, if the current intensity in the voltage circuit is i,

$$U = i\,(R + r) + \frac{i}{2} \cdot x$$

The value of x, which is the combination resistance in the circuit R_1—R_6, has been fixed at 50 ohm. If the resistance r is taken as 75 ohm then $U = i \cdot (100 + R)$, that is the same value as with the connection dealt with above. The resistance in the voltage circuit amounts therefore to 100 ohm per volt.

The measurement range on the current side is determined by the magnitude of the shunt R_s. In this case the value of the resistance will be the same as with the preceding connections. The resistance $R_s{}^1$ is not traversed by the load current I but only by half the voltage circuit current i. Consequently it may be given dimensions for low power. The object of the resistance is to give full symmetry in the connection and its resistance will therefore be the same as the resistance in R_s.

The expression for the power delivered to the object of measurement Z will be exactly the same as for connection with separate current and voltage circuits. Derivation may be done in similar manner. There is thus obtained:

$$P = C \cdot K\,(U_2{}^2 - U_1{}^2)\ \mathrm{W}$$

Voltage Measurement

Fig. 7 shows the connecting diagram for the device when used as voltmeter. The wanted voltage is connected to the terminals U.

In the same way as with power measurement, a certain resultant current A must traverse the current sensitive resistance R_2 so that the bridge R_1—R_4

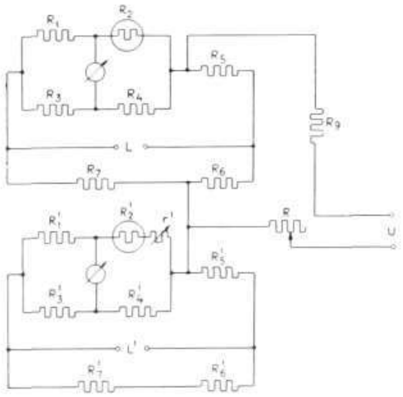


Fig. 7 X 4460

A. C. current potentiometer as voltmeter only may come into equilibrium. If the momentary value of the current through R_2 due to the measurement voltage U is designated by i and the D.C. current from L by I_1 then there holds good for the resultant current's power value the relation

$$A^2 = \frac{1}{T} \int_0^T (I_1 + i)^2 \, dt$$

For the lower bridge circuit as per Fig. 7, which is only traversed by the D.C. current I_2, is hold

$$A^2 = \frac{1}{T} \int_0^T I_2^2 \, dt$$

If the two integrals are put equal there is obtained after simplification

$$I_2^2 - I_1^2 = \frac{1}{T} \int_0^T i^2 \, dt$$

The right hand term is the expression for the square of the power value of the A.C. current in R_2. If this power value is designated by I it then holds good

$$I = \sqrt{I_2^2 - I_1^2}$$

Introducing the values for both the delivered D.C. voltages and the A.C. voltages connected to the terminals, corresponding to the currents in R_2, we get

$$U = K \cdot \sqrt{U_2^2 - U_1^2} \text{ V}$$

The designations K, U_1 and U_2 have here the same significance as in the final equation for power measurement.

Current Measurement

Naturally the connection shown in Fig. 7 can also be used for current measurement, if the series resistance R and the resistance R_9 are replaced by a shunt of suitable dimensions. As may be easily demonstrated it will have a resistance that has the same value as in the connection for power measurement. The value of the current therefore is given by the following equation, where the designations are the same as in the foregoing.

$$I = C \cdot \sqrt{U_2^2 - U_1^2} \text{ A}$$

If there is connected a D.C. voltage or D.C. current instead of A.C. current to the measurement terminals, it is possible also to measure these values. If the D.C. values are inserted in the integrals derived, there is obtained after reduction

$$U = K \, (U_2 - U_1) \text{ V}$$

and

$$I = C \, (U_2 - U_1) \text{ A}$$

Obviously this measurement is of no practical importance, though it provides a method of checking the instrument with D.C.

The Instrument's Connecting Diagram

The complete connecting diagram of the instrument will be seen in Fig. 8. The voltage switch O_1, which has 17 positions and is adjustable between 1 and 150 V, is of simple single-pole type. The current switch O_2, however, must be three-pole partly to eliminate voltage drop in the junction resistance with high current intensities and partly to give the requisite symmetry in the

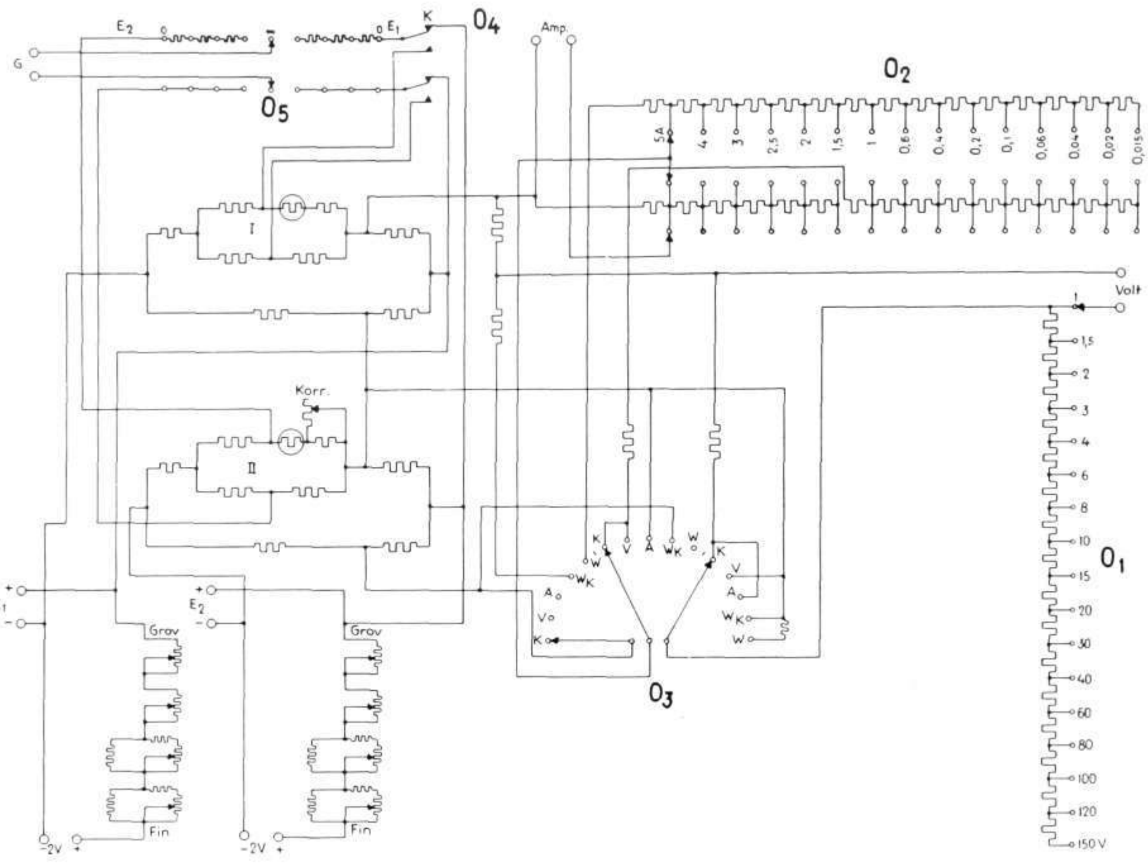


Fig. 8 X 7421

Complete connecting diagram for A. C. current potentiometer

connection. The current switch has 15 positions and is adjustable between 15 mA and 5 A. The nominal measurement range of the instrument as power meter is thus 15 mW to 750 W.

By means of a third switch O_3 change-over to the different measurement ranges is made. This switch is three-pole and has 5 positions. In the positions *V* and *A* the connection is such that the instrument is used for voltage and current measurement respectively, that is corresponding to Fig. 7, whereas position W_k represents connection as per Fig. 5, or for check of wattmeters. For direct power measurement on an instrument corresponding to the connection of Fig. 6, the switch is put to position *W*.

The first position of the switch is marked *K* and is employed for checking that the bridge circuits are adjusted for the same resultant current. With the switch in this position the A.C. circuits are disconnected from the bridges, but they are loaded with the same resistances as when they are connected to the bridges. This is to ensure that the sources of current shall have the same loading, so that the instruments connected do not change their deflection on moving O_3 to another position. The switch O_4 is linked mechanically to O_3 in such a manner that the upper contacts are connected to the galvanometer circuit when switch O_3 is at *K* and the lower contacts are connected to the galvanometer with other positions of O_3.

The galvanometer is connected to the two bridge circuits by the switch O_5. This switch has a home position in the middle and four right-hand and four left-hand positions, corresponding to different series resistances in the galvanometer circuit.

The D.C. currents are regulated by four rheostats in each circuit. To ensure certain adjustment three of them in each circuit are adjustable in steps and the fourth is continuously adjustable for fine adjustment.

The A.C. current and the A.C. voltage that are to be measured are connected to the terminals marked *Amp.* and *Volt* respectively. The galvanometer which should be a relatively sensitive mirror galvanometer is connected in at the terminals *G*. Measurement of the D.C. circuits is done by connecting 2-volt accumulators to the two terminals marked *2 V*. The D.C. voltages are measured by potentiometers connected at E_1 and E_2.

The A.C. potentiometer is built into a wooden case measuring 52 × 35 × 19 cm. The controls and the terminals are fitted on a black enamelled metal panel and are marked as in Fig. 8. The appearance of the instrument may be seen in Fig. 9. The current and voltage switches are located on the right-hand side and the corresponding terminal clamps just opposite the switches concerned. The measurement value switch O_3 for checking and for measurement of voltage, current and power is to the left of the voltage switch. Above it is the galvanometer switch, with the middle position marked ∞ and the outer positions 0. These outer positions correspond to direct coupling of the galvanometer to the two bridges. The third knob marked *Korr.* (correction) in this row is double for fine and rough regulation of the resistance in series with one of the two temperature sensitive resistances. The two terminals at the top are intended for connection of the galvanometer. On either side of these are two pairs of terminals marked E_1 and E_2. These are connected to the potentiometer for measuring of D.C. voltages. The two accumulators are connected to the two pairs of terminals marked *2 V*. The D.C. current is regulated by the 2 × 4 knobs located under the terminals E_1 and E_2 respectively.

Employment of the A.C. current Potentiometer

Before measurements are started, the two 2-volt accumulators should have been connected for one hour to ensure thermic equilibrium. A suitable mirror galvanometer with some tens of ohm internal resistance is connected to the *G* terminals of the instrument and the *E* terminals are connected to the potentiometer. The same galvanometer can quite well be used for the two instruments.

The switch O_3 in Fig. 8 is thrown to *V* and the galvanometer switch O_5 is moved to the right by steps towards E_2. By means of the four right-hand rheostat knobs the D.C. current is regulated until the galvanometer points to zero, even when full galvanometer sensitivity is reached. The upper rheostat (rough) should while this adjustment is proceeding be entirely disconnected

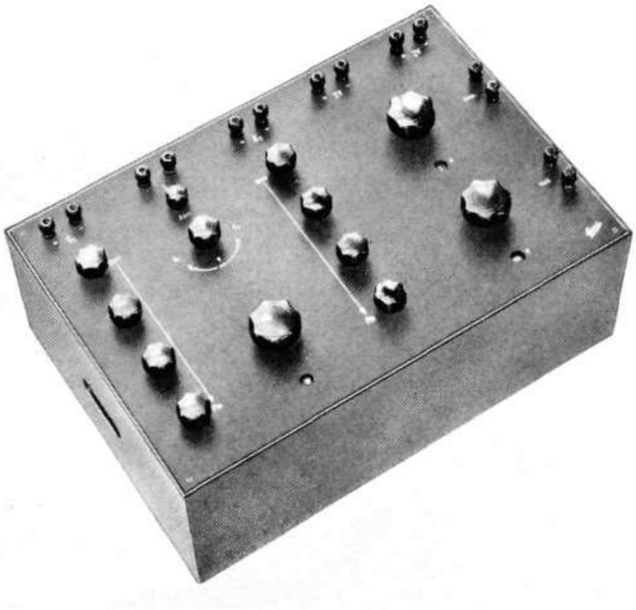


Fig. 9 X 6234

A. C. current potentiometer, type YBH 10 (turned to right). To check the other bridge circuit, O_5 is moved by steps to the left towards E_1, while the D.C. current is regulated by the left-hand rheostat knobs until the galvanometer again registers zero. After these adjustments therefore the galvanometer should read zero for the two outside positions of the galvanometer switch.

Then the measurement value switch O_3 is put to position K. The galvanometer is connected on E_1 (turn to the left) and zero reading is now regulated by the *right-hand* rheostat knobs. With this regulation therefore the same current is adjusted in the two bridges. If now the galvanometer switch E_2 is turned (to the right) the equilibrium in the bridge circuit E_2 (*II* in Fig. 8) is checked. If there now is deflection of the galvanometer this means that the two current sensitive resistances have not the same resistance. By manipulation of the knobs marked *Korr.* the galvanometer is brought to zero. Fresh checking in the position E_1 and possibly adjustment of the right-hand knobs is usually necessary. After adjustment, the galvanometer should read zero for both positions of the galvanometer switch, whatever the position of the measurement value switch, providing that no measurement current is connected to the *Amp.* and *Volt* terminals. The above-described adjustments and checks must be carried out to have the two bridges regulated for the same resultant currents.

The better to show how the actual measurement is done, a practical example will be given: A wattmeter is to be checked at 1 A and 100 V. The current and voltage switches are put at 1 A and 100 V respectively and the measurement value switch turned to W_k is connected to the instrument. Before current and voltage are connected the upper rheostat knobs are turned, that is rough adjustment, to the left so that the D.C. currents are reduced in the bridge circuits. After current and voltage have been connected, the wattmeter reading is 100.0 W.

The galvanometer switch is moved to the right and the right-hand rheostat knobs are regulated until the galvanometer registers zero. The corresponding adjustment is then executed on the left-hand rheostat knobs with the switch in left-hand position. The two D.C. voltages at E_1 and E_2 are measured by the potentiometer as $U_1 = 1.11407$ and $U_2 = 1.49672$ V. From these the real power is computed:

$$P = 1 \cdot 100(1.49672^2 - 1.11407^2) = 99.90 \text{ W}$$

The correction for the wattmeter therefore is —0.10 W.

If A.C. current and voltage are still app. 1 A and 100 V, but these are phase shifted in relation to each other so that the wattmeter registers 20.0 W, the following values are obtained after the D.C. currents have been adjusted so that the galvanometer reads zero for both switch positions:

$$U_1 = 1.30126 \text{ and } U_2 = 1.37545 \text{ V}$$

$$P = 1 \cdot 100(1.37545^2 - 1.30126^2) = 19.86 \text{ W}$$

The correction for 20 W is therefore —0.14 W.

If it is desired to know the real value of the current through the wattmeter, the various purposes switch is moved from the position W_k to position A. Adjustment is done in the same way as before. Result:

$$U_1 = 1.06521 \text{ and } U_2 = 1.49481 \text{ V}$$

Therefore

$$I = 1 \cdot \sqrt{1{,}49481^2 - 1{,}06521^2} = 1{,}0488 \text{ A.}$$

In the same way the voltage can be determined when measuring by throwing the switch to position V. Result:

$$U_1 = 1.11025 \text{ and } U_2 = 1.49480 \text{ V}$$

$$U = 100 \cdot \sqrt{1{,}49480^2 - 1{,}11025^2} = 100{,}09 \text{ V.}$$

On checking the instrument at 100 W, therefore, the power factor was app. 0.95.

As our second example we take the measurement of the no-load loss in a small transformer.

a) The induction $B = 1\ W_b/m^2$ (10000 gauss)
The current constant $C = 0.2$ and the voltage constant $K = 100$. Values measured:
$U_1 = 1.3327$ and $U_2 = 1.4075$ V.
$P = 0.2 \cdot 100\ (1.4075^2 - 1.3327^2) = 4.10$ W.

b) The induction $B = 0.01\ W_b/m^2$ (100 gauss)
Current constant $C = 0.015$
Voltage constant $K = 1$
Measured: $U_1 = 1.4532$ and $U_2 = 1.4592$ V
$P = 0.015 \cdot 1\ (1.4592^2 - 1.4532^2) = 0.00025$ W.

From the examples given, it will be seen that the instrument can be used for accurate measurements, in many cases down to 0.1 %, and at the same time it may be used for very small powers. It is intended in the first place for checking precision instruments and is very much superior to other methods where D.C. is usually employed. The measurements may be done relatively quickly, but the working out of the results requires a certain amount of computation work. This, however, may be considerably facilitated by calculating machines or tables, diagrams and curves. Of course, all real precision measurements always require great care and most often the time taken in measuring is relatively long. The method here described is no exception in this respect.

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Linderoth, M: *New Railway Telephone Plant at Stockholm Central Station.* Ericsson Rev. *23* (1946) pp. 276—282.

A new private branch exchange on LM Ericsson's OS system with a capacity of 2000 lines was installed at the beginning of 1946 for the Swedish State Railways. It replaces an earlier exchange put into service in 1936, also on the OS system, for 900 internal lines. The build up and operation of the new exchange are described in the article, together with some historical information regarding the development and employment of the telephone in the Swedish State Railways system.

U.D.C. 621.395.26

Montell, H: *Automatic Private Branch Exchange Type ALD 20.* Ericsson Rev. *23* (1946) pp. 283—291.

In the article a description is given of LM Ericsson's new automatic private branch exchange, type ALD 20, for 20 extensions and 5 public exchange lines and equipped with all modern facilities. The exchange works with rotary step-by-step driven 25-line selectors and consists of a rack on which are fitted all the devices, including distribution. The establishing of internal calls and outgoing public exchange calls is done automatically. The connecting devices of the exchange for internal traffic are not occupied for external culls. Incoming public exchange calls are handled semi-automatically over a switchboard in which each extension has its own ringing key, employed instead of dial in connecting up the extension. Thanks to these keys the work of the operator is facilitated and at the same time the handling of the call is very rapid.

U.D.C. 621.395.24

Montell, H: *ALD 10 — a New Automatic Private Switchboard.* Ericsson Rev. *23* (1946) pp. 292—296.

LM Ericsson's new automatic private switchboard for up to 22 extensions and with three or four call facilities is described in the article.

The switchboard is chiefly intended for use in small offices and factories, in large residences etc. In working out the switchboard, particular attention has been devoted to efforts to produce a type of switchboard requiring a minimum of maintenance and operating reliably even with great variations in the working tension. The current supply of the switchboard may consist either of charging unit with booster battery or of a battery eliminator.

U.D.C. 621.317.7

Holmqvist, S: *Alternating Current Potentiometer.* Ericsson Rev. *23* (1946) pp. 297—307.

The alternating current potentiometer differs in principle from earlier A.C. potentiometers in which a direct comparison between the wanted A.C. voltage and a known A.C. voltage was made. For such comparison the two voltages must be the same in respect of frequency, shape of curve and phase angle. In practice it is not possible to attain this, if any great degree of accuracy is desired.

With the new principle, the wanted A.C. values, current, voltage or active power are transformed into direct current voltages, which are measured with D.C. potentiometers. From these measurements it is then possible to compute the wanted A.C. values. The transforming is done by thermic means, so that in principle the value will be unaffected by frequency, shape of curve or phase angle. Naturally, for practical reasons, there arises a limitation of the independence of frequency owing to the angle of error of the resistances and capacitive leakances. The apparatus described is intended mainly for main frequencies.

Ericsson LM